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ELEMENTS

Of the ART of

ASSAYING METALS.

In TWO PARTS.

The First containing

THE THEORY,

The Second

THE PRACTICE

of the said ART.

THE WHOLE

Deduced from the true Properties and Nature of
Fossils; confirmed by the most accurate and
unquestionable Experiments, explained in a na-
tural Order, and with the utmost Clearness.

Written originally in Latin, by

JOHN ANDREW CRAMER, M.D.
WITH

NOTES and OBSERVATIONS not in the ORIGINAL,
particularly Useful to the *English* Reader.

By CROMWELL MORTIMER, M.D.
Secretary to the ROYAL SOCIETY.

To which is prefixed

A LIST of the Chief *English* Authors who have written
upon Minerals and Metals.

THE SECOND EDITION, corrected.

LONDON,

Printed for L. DAVIS and C. REYMERS, against *Gray's Inn Gate*,
Holborn: Printers to the ROYAL SOCIETY.

MDCCLXIV.

ADVERTISEMENT

TO THE

SECOND EDITION.

THE principal Parts of this Treatise were first disposed into Order, to serve as Materials for a Course of Lectures and Experiments; which, in the Year 1737, were given at *Leyden*, to a Society of Gentlemen, most eminently distinguished for their Skill, in all Branches of Natural knowledge. This will be readily allowed, when it is known, that *Van Swieten* and *Gronovius* were of the Number. *Cramer*, who had collected the Chief of these Materials, and made the Experiments, had been instructed in Mineralogy, and in the Practice of Metallurgy, by the greatest Masters in *Germany*; and at the time above-mentioned, and for some Years before, was employed by Doctor *Isaac Lawson*, as his Operator in Chemistry. This last named Gentleman, had resided much longer at *Leyden*, than those Foreigners usually do, who go there to qualify themselves for the Practice of Physick. He then employed himself in the Cultivation of those Arts which he had there been taught; particularly, of Chemistry; and was highly esteemed for his Skill therein; and lived in great Intimacy, with *Boerhave*, *Van Swieten*, *Gaubius*, *Gronovius*, *s'Gravesand*, *Albinus*, and with several other Men of great Learning, who resided in that University, and which was then in its most flourishing State; as also with *Linnaeus*, who was occasionally there. Doctor *Lawson* afterwards served as Physician to the *British Army* in *Flanders*; where, by his Death, in

the Year 1745, the World was deprived of the Advantage of many useful Discoveries. To him we owe several of the Observations contained in this Work, to which *Van Swieten*, *Gronovius*, and others of the learned Gentlemen before mentioned also contributed. But the Care and Trouble of reducing the Materials into Order, and writing them out fair for the Press, devolved entirely on Doctor *Lawson*, as fully appears from his Letters to the † Gentleman who hath supplied us with these anecdotes, and who, in Justice to the Memory of so worthy a Man, thought proper to make known how much he had contributed, to this Performance. If any Thing can add to the high Reputation of this Work, it must be the Knowledge of its having been composed under the Direction and Patronage of Men so distinguished for their Knowledge in Natural History, and in every Branch of the Chemical Art.

In this SECOND Edition, the *List of English Authors* has been enlarged; and the References to the Philosophical Transactions of the Royal Society, brought down to the Year 1764.

† Doctor Brownrigg.

PREFACE

P R E F A C E

TO THE

FIRST EDITION

In 1741.

I SHALL, in this compendious Work, give the Reader the Elements of the Art of Assaying, that is, that Part of Chemistry, which consists in a strict Examination of Minerals, by Means of a proper Apparatus. I have written this chiefly, that it may be of use to such Lovers of Chemistry as apply themselves to the Study of mineral Matters. For this Reason, supposing that some of the slightest and most common Chemical Preparations were in some measure known to the Reader, I have been very short about them, when I have had Recourse to them in the Practical Part of the docimastical Art, except perhaps in some Places, that required a more particular Description, as being little taken Notice of in the common Chemical Processes. Therefore I thought it proper, previously to give a short and special Theory of this Art, that those who should come to the Processes, might already be acquainted with certain Things necessary to be known; that by this Means the Mind might be more completely Instructed in the making of the Apparatus, and the different Manners of proceeding be more easily understood. I have begun this Theory by an Explication of the less compound Objects of the Art, that these being found pure, might be distinguished by their outward Form, or by the slightest Trial, especially in the Fire. The simple Stones have rendered this Matter the most difficult: For

almost all Authors have settled the different Classes of them only from their Figure, Transparency, Colour, &c. which Method, however, can be of little service for our Purpose, and even in general. Thence it is, that there are Exceptions in every one of these Classes, on Account of some Resemblance with regard to the Particulars just mentioned: So that Stones, which are called by some general Name, do not always resemble each other as to the other Characteristics, even the more essential, which for this Reason ought not to be neglected upon any Account. And as it is no small Help towards a solid Knowledge of Compound Minerals, to know the Action of the simple Ones upon each other, provided one has a Regard to the Conditions requisite in every Case, and no unseasonable Fictions are admitted; I have for this Reason explained the Virtues of the Menstrua in the second Chapter. In the mean time, let none expect to have this Matter completely treated here; I mean as far as it is known from the Experiments hitherto made; because it cannot be exactly known otherwise than from the Processes themselves. Therefore, I have inserted very few of these, and even none but such as might be confirmed by the easiest Trial. Had I done otherwise, I must have supposed that many Things were already known to the Reader, which are familiar only to experienced Artificers, to whom it would have been an useless Trouble to propose them. I have, for the same Purpose, given a Description of the Instruments.

It is easy to conceive, that it has not been in my Power to mention all compound Minerals, on Account of the numberless Differences proceeding from their various Qualities, Proportions, and Compositions. Wherefore, I would have what I have said on these Matters, considered only as a Specimen, which, however may be very useful, and even necessary to young Beginners.

I have added a short Description of the Works which are chiefly and strictly Docimaſtical, to which I have annexed Explanations of the Terms. Then follows a ſhort Account of the Effects, and of the Utilities reſulting from them in ſeveral Arts and Sciences, as far as theſe Things can be underſtood here. This is what I had to ſay concerning the Order I have propoſed to myſelf in treating this Theoretical Part.

But, as I have, for ſhortneſs Sake, ſeldom quoted any Authors in this Work, I ſhall here mention in general thoſe from whom I have borrowed; though an indefatigable Labour, the cloſeſt Inſpection, and Hands that were not afraid of the Blackneſs of Charcoal, have indeed been my chief Maſters in this Art. As to the Theory of it, Dr. *Stahl* has, in a clear Manner, given us the Principles thereof in many of his Writings. Dr. *Henckel* has given us Inſtructions about compound Minerals, and chiefly about metallick Ores, eſpecially in his *Pyritology*. Mr. *Ercker*, in his Treatiſe written in *Germany*, called *Probiere-Buch*, and *Agricola*, in his Treatiſe *De Re Metallica*, Lib. VII. have given us the Proceſſes themſelves, to which *Modest. Faſchens* has added ſome few Things of his own. As to the other Authors, they have borrowed all the Materials from thoſe above-mentioned, or have not been made uſe of by me, becauſe I knew them not.

If the Reader approves of this Work, he may expect ſome others, that will perhaps be more elaborate.

A
L I S T
OF THE
Chief ENGLISH AUTHORS,
WHO

Have treated of MINERALS and METALS.

W. LEWIS, M. B. F. R. S. *Commercium Philo-
sopho-Technicum*, Lond. 1763, 4to.

I. F. Henckel : *Pyritologia, or, a History of the
Pyrites*, Lond. 1757, 8vo.

M. da Costa : *A History of Fossils*, Lond. 1757. 4to.

Llhwyl : *Lithophylaceum Britannicum*, Lond. 1699
and Oxf. 1763, 8vo.

William Borlace : *The Natural History of Cornwall*,
Lond. 1758, Folio.

Gabriel Plattes : *A Discovery of subterranean Trea-
sure, viz. Of all Manner of Mines and Minerals from
Gold to the Coal, with plain Directions and Rules
for the finding of them, in all Kingdoms and Coun-
tries, &c. This small, but curious Tract hath often been
printed at London in 4to; and lately in 8vo. at the
End of a Translation of Alonso Barba.*

Alvaro Alonso Barba : *Art of Metals*, the 1st and 2d
Book, translated from the *Spanish* by *Edward Earl of
Sandwich*, Lond. 1674, in Two Parts, 8vo, and lately
reprinted. N. B. The Original is in five Books.

John Webster : *Metallographia, Or an History of
Metals, &c.* Lond. 1671. 4to.

Robert Boyle, Esq. *General Heads for the natural
History of a Country*, Lond. 1692, 12mo. *In this
Book the Author lays down various judicious Rules
for the Discovery of Ores and Minerals. Many curi-
ous Things relating to Metals and Minerals, are to be
found dispersed in his philosophical Works.*

Sir

Sir *John Pettus*: *Fleta Minor*; the Laws of Art and Nature in knowing, judging, assaying, fining, refining, and enlarging the Bodies of confined *Metals*, in Two Parts. The first contains Assays of *Lazarus Ercker*, Essay-master General of the Empire of *Germany*; in Five Books, originally written by him in the *German* Language, and intituled *Aula Subterranea*. The Second contains Essays on metallick Words, as a Dictionary to many pleasing Discourses, *Lond.* 1686, Folio.

John Houghton: A Collection for the Improvement of Husbandry and Trade, 4 Vols. *Lond.* 1727. 8vo.

In Vol. I. You have some Observations

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Of Soap, No 405.

In Vol. IV.

Of Minerals, &c. p. 290—1—2.

Of Salt Spanish, French, Portugal, Scotch, and Newcastle, p. 454, &c.

John Ray: A Collection of English Words not generally in use. To this Book is subjoined an Account of the preparing and refining such Metals and Minerals as are gotten in England, Lond. 1737, 8vo. viz. the fining Silver in Cardiganshire. The Preparing and Smelting Tin in Cornwall. The Manner of the Iron-work at the Furnace and at the Forge. The Wire-work at Tintern in Monmouthshire. *Modus faciendi Vitriolum coëtile in Anglia*: From Wormius in his Museum. The making of Minium or Red-lead. The Allum-work at Whitby in Yorkshshire. The making Salt at Namptwych in Cheshire. The Manner of making Salt of Sea-sand in Lancashire.

John Lawrence: A new System of Agriculture, Lond. 1726. Folio. In this Work is inserted what he hath collected

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Ant. Neri: Art of making Glass, with Notes by Kunkel and Merret, Lond. 8vo.

H. Blancourt: The Art of Glass, Lond. 1699 8vo.

Pyrotechnical Discourses, containing

John Kunkel: An Experimental Confirmation of Chemical Philosophy, &c. *George Ern. Stahl*: A short Discourse on the Original of Metallick Veins. *John Christ. Fritschius*: The Grounds of Pyrotechnical Metallurgy, and Metallick Essaying.

These Treatises were translated from the Latin by Mr. John Moulton, Chemist; but there being in the Original many Sentences of German interspersed,

persed, he hath left them untranslating, probably not understanding that Language, Lond. 1705 8vo.

Robert Plot L. L. D. *Natural History of Staffordshire.* Oxford 1686. in Folio. of Coal-pits, Chap. III. § 31, 32, 34, 36, 37, 60, 61, 62.

Charles Leigh, M. D. *Natural History of Lancashire, Cheshire, and the Peak in Derbyshire,* Oxf. 1700 Folio.

Edward Brown, M. D. A brief Account of some Travels in divers Parts of Europe, &c. with some Observations on the Gold, Silver, Copper, Quicksilver Mines, &c. of Hungaria, &c. Lond. 1685, Folio. and 4to.

William Waller: An Essay on the Value of the Mines late of Sir Carbery Price, Lond. 1698, 8vo.

The *Philosophical Transactions* of the Royal Society

Tripoly, Vol. li. part 1.

Marble, Vol. li. part 1.

Giants Causeway, No 485. Vol. xlviii. part 1.

Vol. xlix. part 2. Vol. lii. part 1.

Pebbles, No 483.

Asbestos, Vol. li. part 2.

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Vol. li. part 2.

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Turquoise, or Copper Ore, No 482. Of Brass,
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Derbyshire Fossils and Petrefaction, No 456,
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Figured-Fossils, No 482, 490, 496. Vol. xlviii.
part 2. Vol. xlix. part 1. Vol. xlix. part 2.
Vol. l. part 1. Vol. l. part 2. Vol. li. part 2.

William Brownrigg, M. D. F. R. S. The Art of
making Common Salt, as now practised in most parts
of the World; with several Improvements proposed
in that Art, for the use of the *British* Dominions.
N. B. In this work is included the Art of preparing
Bay-Salt, 8vo. 1748.

For the Sake of such as understand *Latin*, we must
not pass by that magnificent and laborious Work of
Emanuel Swedenborgius, intituled, *Principia Rerum
Naturalium, sive novorum Tentaminum Phænomena
Mundi Elementarii Philosophice explicandi. Dresdæ &
Lipsiæ 1734*, in 3 tom. in Folio; in the 2d and 3d
tomes of which he hath given the best Accounts, not
only

only of the Methods and newest Improvements in metallick Works in all Places beyond the Seas, but also of those in *England*, and our Colonies in *America*; with Draughts of the Furnaces and Instruments employed. It is to be wished we had Extracts of this Work in *English*. So industrious are the *Swedes* in improving themselves in the Art of Metallurgy, that they send young Gentlemen yearly to travel, not only all over *England*, but all over *Europe*, to learn every Thing new in regard of Mines; while we in *England* sit still at Home, and seldom go beyond a County or two; though, if more diligent Search was to be made by Persons of Skill, there is great Reason to believe that Nature hath enriched these our Isles with as great subterranean Treasures, even the Virgin Silver of *Potosi* not excepted, as any other Spot of the same Extent.

Some brief Directions for making Observations and Collections, and for composing a travelling Register of all Sorts of Fossils, wherein are many good Rules for discovering Minerals and Ores, are printed at p. 99, &c. of the Appendix to

Dr. Woodward's Fossils of all Kinds digested into a Method, 8vo. 1728.

As for Catalogues of Minerals and Ores already known in *England*, see

Christopher Merret: Pinax Rerum Naturalium Britannicarum, continens Vegetabilia, Animalia & Fossilia, Lond. 1667. 8vo.

Nebemiah Grew, M. D. Musæum Regalis Societatis, or a Catalogue and Description of the natural and artificial Rarities belonging to the Royal Society, Lond. 1681, Folio. But the most compleat is that elaborate Work,

Dr. Woodward's Attempt towards a natural History of the Fossils of England, Lond. 1729, 2 vol. 8vo.

Concerning the *English Laws* relating to Mines and Metals, you have a Proposal for Laws by *Tho^o Houghton*, in his *Golden Treasury*, or the *Compleat Miner*, being Royal Institutions or Proposals for Articles to establish and confirm Laws, Liberties, and Customs

Customs of Silver and Gold Mines, to all the King's Subjects, in such Parts of *Africa* and *America*, which are now or shall be annexed to, and dependent on the Crown of *England*, &c. *Lond.* 1699, 12mo.

The same Author hath given us another small Treatise, entituled,

Rara Avis in Terris, or the compleat Miner, in two Books: The first containing the Liberties, Laws, and Customs of the *Lead Mines* within the Wapentake of *Wirksworth* in *Derbyshire*. The second teacheth, the Art of dialling and levelling Grooves, a Thing greatly desired by all Miners; being a Subject never written on before by any, with an Explanation of the *Miners Terms* of Art used in this Book, 1681, in 12mo.

Sir *John Pettus*: *Fodinae Regales*, or the History, Laws, and Places of the Chief Mines and Mineral Works in *England*, *Wales*, and the *English* Pale in *Ireland*. As also of the Mint and Money. With a Clavis explaining some difficult Words relating to Mines, &c. Folio. 1670.

The several other *Laws* now in force are scattered up and down in the *Statutes* at large: But that which gives the most Encouragement to Miners and Metallurgists, is the famous *Statute* procured by the Interest of the great Mr. *Boyle*, Anno 1 *Gul.* and *Mar.* Chap. 30. intituled, An Act to repeal the Statute made in the fifth Year of King *Henry IV.* against multiplying Gold and Silver:

Wherein it is enacted, that all Gold and Silver that shall be extracted by the Art of Melting and Refining of Metals, and otherwise improving of them and their Ores, be from henceforth employed for no other Use but the Increase of Monies; that it be carried to the Tower of *London*, where the owner shall receive the full Value. And that for the future no Mine of Copper, Tin, Iron, or Lead, shall be hereafter adjudged a Royal Mine, though Gold or Silver may be extracted out of the same.

Anno 5 *Gul.* and *Mar.* Chap. 6.

An Act to prevent *Disputes* and *Controversies* concerning *Royal Mines*. In

In this Act it is enacted, that any Person, &c. that now is or shall be Owner, &c. of any Mine or Mines in *England*, wherein is Copper, Tin, Iron, or Lead, may keep and work such Mine, &c. notwithstanding it shall be pretended or claimed to be a Royal Mine; provided always that their Majesties, &c. and all claiming under them, may have the Ore of any Mine (except the Tin-Ore of *Devon* and *Cornwall*) paying to the Proprietors, &c. of the Mine within 30 Days after the Ore is raised, for all Ore washed, made clean, and merchantable, wherein is

Copper 16*l.* per Tun. Tin 2*l.* per Tun.

Iron 2*l.* per Tun. Lead 9*l.* per Tun.

And in Default of Payment of such Prizes, the Owners of the Mines may sell the said Ores to their own Uses.

Since these Encouragements we see great Quantities of *Silver Coin* made of Silver extracted out of Lead in *England* and *Wales*: These Coins have in the Quarters between the King's Arms upon their Reverses, Roses or Feathers, or both alternately. In the Cabinets of the Curious are also found Shillings of Queen Elizabeth, with an Escallop Shell instead of the Queen's Head; they were coined (without Royal Licence) by one *Pudsey*, of *Rimington*, in the West Riding of *Yorkshire*, who got good Store of Silver Ore from his Estate there.

The *Laws* relating to wrought *Plate* were formerly collected into a small Volume, which it is pity we have not a new Edition of, with the Addition of all the new Statutes; the Title was,

A Touch-stone for Gold and Silver Wares, or a Manual for Goldsmiths. By *W. B.* of *London*, Goldsmith. *Lond.* 1677, 8vo.

Mineral Laws of Derbyshire, 1734, 8vo.

Laws and Customs of Miners in the Forest of Dean, in the County of Gloucester, 1687, 12mo.

Pearce's Laws and Customs of the Stannaries in Cornwall, and Devon. *Lond.* 1723, Folio.

Opera Mineralia Explicata, &c. *Lond.* 1718, 8vo.

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THE
ART
OF
ASSAYING
METALS.

PART the FIRST,
Being the THEORY of ASSAYING.

CHAP. I.

Of the Definition and Object of ASSAYING.

1. **A**SSAYING * is the Art of Separating Metals, Semi-Metals, Sulphurs and Mineral Salts from each other, and from other Bodies mix'd with them, so that it may appear, what Quantity there was originally of each in the Body under Tryal, or what Benefit may be reaped from the extracting of it.

2. All Minerals are the Objects of this Art: For the Bodies aforesaid being seldom found naturally pure, and under their true Form, but most commonly mix'd and confounded with each other a thousand different Ways, and with many kinds of Earths and Stones; it is proper that the Workman should know

* A Corruption, by the Workmen, of the Word *Essay*ing, derived from the French *Essayer*, to try.

The ART of

the Nature of all these Things, to be able to determine, what is requisite for the Separation of them.

3. I shall, with the most renowned Dr. *Boerhaave**, call *Minerals* and *Fossils* natural Bodies, formed in the Bowels of the Earth, or in its Surface, and whose Frame is so very simple, that no Eye, tho' ever so sharp, has been able even with the best Microscopes hitherto to discover in them any Variety, between the Parts containing, and the Things therein contained; but a perfect Likeness and Affinity of the Parts with the Whole: Though it is known that in most of these a Concurrence of fluid and solid particles hath been effected by certain Mixtures.

Corollary. He therefore that attempts to give a rational Account of the Art of Effaying, ought previously to give such a Description of the simpler Species of Minerals which enter into the Composition of the Concretes, as may be taken from their external Form, from their being simply put into the Fire, and from other slighter Experiments hereafter to be mentioned.

4. All Minerals hitherto known, may be referred to five Classes, *viz.* Metals, Semi-Metals, Salts, Sulphurs, Stones and Earths.

I. Of METALS.

5. *Metals*, when pure, are Bodies extremely ponderous, fusible by several Degrees of Fire, solid in the natural Heat of the Atmosphere, apt to be extended every way with the Hammer, and of the utmost Opacity. They are six in number, *viz.* Gold, Silver, Copper, Lead, Tin, and Iron.

6. Gold, *Sol*, whose Mark is (☉), has all the Characteristics (§ 5.) of Metals in their utmost Perfection. It loses between $\frac{1}{19}$ and $\frac{1}{20}$ of its Weight, in pure distilled Water. Though ever so long kept in a State of Fusion, and in the greatest Fire, it loses nothing of its Substance; as it is of a most fix'd Nature. It is infinitely malleable; it gives no Sound

* Elem. Chem. Vol. I. p. 30.

when struck; in the Fire it no sooner whitens, but it melts; and then looks of a Sea-green at the Surface. *Aqua fortis* has no Power on it. Its distinguishing Colour is yellow.

Scholion. *The Operations hereafter to be made upon Gold, and which I suppose are as yet unknown to the Reader, will give him a more exact Idea of this Metal. I may say the same of the other Metals.*

7. Silver, *Luna* (♀) loses $\frac{1}{11}$ or $\frac{3}{22}$ of its Weight in Water: In Fire it is as fix'd as Gold and melts in almost the same Heat. Next to Gold it is infinitely malleable, and easy to be bent. It resists the best *Aqua Regis*, and is of the finest shining white.

8. Copper (♀) *Venus*, loses between $\frac{1}{8}$ and $\frac{1}{9}$ of its Weight in the same Water. It is not very fix'd in Fire, but loses a great Part of its Substance, in Exhalation and Dross. It is likewise malleable, but much less than the foregoing. It gives a loud Sound, looks of a deep yellow, is not fusible but by a great Heat, and no sooner begins to whiten, but tinges the Fire with a most beautiful blueish green. All Salts, and Things containing Salts, corrode it, when applied to it, in which case it assumes a great Variety of Colours, especially the finest green or blue.

Scholion. *Fossils are here said by me to be turned into Scoriæ or Dross, if, when exposed to the Fire, they assume the Form of Glass; a brittle Body, fusible and fix'd in Fire, and indissoluble by Water.*

9. Lead (♀) *Saturnus*, loses between $\frac{1}{11}$ and $\frac{3}{22}$ of its Weight in Water. It melts long before it reddens. It is not fix'd, but loses much of its Substance by Evaporation in a great Fire, and, according to the Degree of Heat, turns entirely into a dusty or a vitrescent Dross, of a yellowish Colour, called Litharge (*Lithargyrium*.) It is very tenacious, and the softest of Metals. It gives hardly any Sound under the Hammer, and is of a bluish white Colour.

10. Tin, (♀), *Jupiter*, is the lightest of all Metals, It loses $\frac{1}{7}$ of its Weight in Water. It is not of a fix'd Nature, but melts in a mild Fire, long before

it becomes red hot. It, in a short Time, partly evaporates into Smoak, and partly becomes a *Calx*. It is less malleable than the foregoing, tho' not very hard: If bent, it makes a crackling Noise, its Colour is much like that of Silver.

11. Iron, (δ) *Mars*, loses between $\frac{3}{8}$ and $\frac{1}{8}$ of its Weight in Water. It is extremely fix'd in Fire, which must be in its highest Degree to melt it: When in Fusion, it loses a considerable Part of its Substance; it sparkles, it dissolves into a Glass of a dark blue Colour, and into sulphureous Vapours: It is the most rigid of Metals; however, if it is not immediately quenched upon being red hot, it is malleable enough, it is of a watery Colour, and is attracted by the Loadstone.

12. Quick-Silver, (ξ) *Mercurius*, though it has no other metallick Quality but its Ponderousness, yet is almost universally reckoned a seventh Metal. It loses $\frac{1}{4}$ Part of its Weight in Water. When pure, it is ever fluid, even in the coldest Weather, and of course not malleable. It has the brightness of Silver, and is of the utmost Opacity; being resolved into Fumes by a middling Fire, it evaporates entirely, a very few reddish Grains like Sand excepted. These Vapours, however, being collected, return into the same Mercury as before.

Scholion I. *These are the Characteristicks of the purest Metals, when separate from each other. They therefore are not good, when two or more of them are mix'd together. For Instance, Copper, Silver, and Gold, when melted together with Tin, lose their Malleability, change their Colour, &c.*

Scholion II. *The specifick Gravities of Metals cannot be very exactly determined; for they vary a small Matter; first, according to the different Heat of the Atmosphere, which expands Water and other Fluids infinitely more than it does solid Bodies; and, by that unequal Diminution of the Weight, makes it impossible to assign them a constant Proportion, unless the Heat be determined with the greatest Exactness. Secondly, according to the several*

ral Degrees of Pureness in the Water; which Difference is sometimes found not inconsiderable. Thirdly, According to the different Pureness of the Metals: For there is hardly any Metal found so very pure, but what may easily be demonstrated to be mix'd with some others. Fourthly, According to the several Weight of the Atmosphere itself: Though the Effect of its Variations be not very considerable. This accounts why there are as many different specifick Gravities assigned to Metals, as there are Authors that have searched this Matter by Experiments. However, unless the Metals be of a very great Impurity, the Sum of all the Differences resulting from the said Causes is not sufficient to hinder any particular Metal to be distinguished from any other by its specifick Weight.

II. Of SEMI-METALS.

13. These agree with the foregoing, except that they have not near the same Malleability, if even they have any. They are as follow.

14. *Zink*, is a Body of a blueish white Colour; brittle and somewhat tenacious; of consequence somewhat malleable, though much less than Metals. It melts in a gentle Fire, soon after it smoaks, and then sticks to the Furnace in the Form of exceeding light white Flowers. In a greater Fire it burns with a Flame of the most beautiful-green Colour, which evidently betrays an Abundance of Sulphur.

15. *Bismuth, Tin-Glass*, when broken, appears to consist of small cubic Particles, and these again consist of minute *Laminas* applied to each other. It is more brittle than the foregoing, but differs little externally, except that it does not assume the blue Colour, but looks rather of a shining and very light yellow.

16. *Regulus of Antimony*, is extremely brittle. When perfectly cleansed from Sulphur, it surpasses the foregoing in whiteness: It requires a greater Fire to be melted; which renders it easy to be distinguished from the two former.

17. There is among the Minerals another Body, which deserves to be classed among the Semi-Metals,

on account of its vast Affinity to them, viz. *Arsenick* (○○). This, if perfectly pure, must be white; it grows soft in the Fire, and then evaporates entirely into a thick white Smoke, that has the unpleasant smell of Garlick; but when grown cold, it gathers into a solid, half transparent, ponderous, white body. It is not inflammable. When exposed to the Air, it assumes a small milk white-Skin; it may be reduced into a *Regulus*, very much like Antimony, and inflammable.

Corollar. Some refer Arsenick to the Class of Sulphurs; but very improperly, as it plainly appears from the Comparison of its Characteristicks just mentioned, with those of Sulphurs.

III. Of SALTS.

18. Salts are Bodies dissoluble in Water, melting or volatile in the Fire, but not inflammable.

19. First of all, there are two kinds of pure and natural Salts among Minerals; one neutral, the other acid.

20. The neutral is of two Sorts; the first is common Salt (⊖), *Muria*, which, if pure, is always of the whitest Colour. It is semipellucid, dissolves in pure Water, thickens in a gentle Fire, appears to consist of several tessellated, cubical and hexaëdral Crystals, joined together in truncated Pyramids; it crackles very loud, when thrown into the Fire.

21. The other is called Nitre (⊕), which, when dissolved in pure Water, and crystallized, according to Art, assumes a prismatical hexaëdral Figure, terminated by small pyramidical Columns of the same Number of Angles. It is white, and nearly transparent. In a pure Fire, such as the Rays of the Sun collected, or in Vessels defended from any Fuel falling into them, it grows liquid by a gentle Heat: In a great Fire, it partly perspires through the Vessels, and partly resolves into a Smoke, which is the Nitre itself; but, any inflammable Body being added to it, it burns with a ve-

ry great Noise, and, with the Matter added, changes in part into an *Alkali*.

22. There is also an acid Salt, called *Vagum Fossile*, found in Vitriol, Sulphur, Allom; nay, almost every where: It is seldom pure, if ever; but adheres either to Metals (and chiefly to Copper and Iron) or to calcareous Earths, more commonly to those that turn into Glass, nay to the very Flints; or is mix'd with inflammable Fossils. But what distinguishes it from all others is, its being more ponderous and more fix'd than all the other Acids that are known, which it drives out of its *Matrices*; mix'd with pure Water, it grows very warm; it mixes with common *Sulphur*, accompanied with fat Matters of any kind. What its Power upon Metals is, will be shewn hereafter, in our Chapter of *Menstrua*.

23. To this Class might perhaps be referred the Acids of common Salt and Nitre. However, as they can be extracted by Chemists from these Salts, only, it is not very sure that they are found naturally any where.

Corollar. It is a question whether there may be found, naturally, any true and perfect Alkaline Salt, whether fix'd or volatile, in the mineral Kingdom? The former seems to be confirm'd by the Salt of the *Spa* Waters, and by the *Natrum* of the Ancients: Marble, and Stones either fetid or easy to be cleft, possibly contain the latter. But both Points require a more accurate Examination. See *Fr. Hoffman** and *Henc-kel*†.

IV. Of SULPHUR.

24. Whatever is inflammable, is called among the Chemists by the general Name of *Sulphur*. You find it in the mineral Kingdom, always mix'd with Acid, (§ 22.) otherwise the pure inflammable Mineral seems not to differ from the vegetable and animal; nor does

* Differtat. Physico-Chem. Lib. II. Obs. I.

† Tractatu de Appropriatione, pag. 126. n. 4.

it seem that there are two kinds of it in Nature: In this Case the whole Difference between the several kinds of *Sulphur*, would consist only in their various Mixture with heterogeneous Matters. As therefore Nature hardly affords any pure inflammable Matter, this is not the Place to treat of the several kinds of *Sulphurs*, which are never without Mixture: Our Design requires, that we should mention those only that are of the simpler kind.

V. Of STONES and EARTHS.

25. *Stones* are Bodies not dissolvable by Water, not malleable, not inflammable, of the most fix'd Nature, and perfectly coherent.

26. When they consist of minute impalpable Particles, little or not at all coherent, they are called *Earths*.

27. But when, being visible, palpable, and extremely small, they nevertheless appear still minute Stones heaped together, they are called *Sand, Gravel, and Grit*.

28. Our Design chiefly requires, that we should shew the Differences of Stones, resulting from their different Changes in the Fire: Nor will it be needless to point out such of their other Characteristicks, as are easily apprehended by the Senses.

29. Some of them will melt in the greatest Heat of a Wind Furnace, and are said to be of the vitrifying Kind: To which Class they are referred.

Nº 1. *Schistus*, or *cleaving Stone*, which is a Stone consisting of a heap of *Laminas* that cleave easily; it is opaque, very soft, most commonly black, in which Case it is harder, and goes by the Name of *Slate*, otherwise it looks of a dark blue, or ash-colour. These Stones, put in Vessels closely shut, sustain a moderate melting Fire, without any Alteration; when the Heat is increased, they are put in Fusion; and then the first black kind of them turns into a clear black Glass. But some of the other Species are by the strongest Fire raised up into a Scum, insomuch that a small Quantity of

of them will fill a large Vessel, and then turn into a very spongy and light Mass, that swims upon Water.

N^o 2. Common *Potter's Clay* is heavy, and of a whitish blue Colour; in Water it softens into a tenacious Paste; a middling Fire hardens it first, and a stronger Fire at last runs it into a Glass of a dark green Colour.

N^o 3. The *Boles* and *Terræ Sigillatæ*, or *sealed Earths*, have an Affinity (N^o 2.) with the foregoing, but are of a faster Nature, and of different Colours. They harden to such a Degree in a modern melting Fire, that they most commonly give Sparkles, when struck with a Flint; in a stronger Fire, they turn into Glass, partly solid and green, and partly spongy and light, (as N^o. 1.) To this Class belong a few Earths of the Nature of Marle, though not quite so fat.

N^o 4. *Flint*, which is a vastly ponderous Stone, when struck with a Steel, gives very bright Sparkles, which, being examined with the Microscope, prove to be *Scoriæ* of melted Iron and Stone. It is infinitely hard, and of a great many Colours. It assumes a multitude of different Names, according to the Variety of its Colour, for the Beauty of which it is very much valued, though in consideration of its Size it is sometimes of no Price at all. If this Stone, either in its natural Surface, or when broken, is very cutting and full of Angles, it is called by the Miners *Quartz*: Some of them are easily put in Fusion in a Wind Furnace; others resist the greatest Fire without hardly any Alteration, and might be thought not to belong to this Class; but, by means of a small Quantity of Salt, or some other *Menstruum*, nay by means of the *Alkali* in the Coals, they will melt in a naked Fire. When they are only minute Flints like Grains, heaped together, but not adhering to each other, they are called *Sand* or *Gravel*. But when they stick together, though distinctly collected, they are called a sandy or gravelly Stone, which is of the same Nature as the Flint, and assumes in the Fire a Variety of Colours, Forms and Delicacy.

30. *Limestones* constitute another kind, which, when burnt in the greatest Fire, are so changed as either to soften in the Fire immediately, or to cleave into Lime by adding Water to them. Of this Class are,

Nº 1. *Spathum*, or *Spaad*, which is a soft Stone, and will be render'd so very brittle by the mildest Fire, in which it makes a gentle Crackling, that you may reduce it into Dust between your Fingers. It varies its Gravity, as it is more or less compact. It most commonly consists of *rhomboidal*, often of prismatical, parallel, and oblong Parts, variously transparent, and generally of a watery or milky Colour..

Nº 2. *Marbles*, which are of a great many Colours, and often of various Colours at once. Marble is a hard Stone, most commonly opaque: If, after having been burnt in a great Fire, it is exposed in the Air, or wet with Water, it generally cleaves with great Violence into a thin limy Powder: But this still has an Exception; for there are Marbles extremely neat and fine, which, in a Fire not over-violent, turn into an opaque kind of Glass, but not at all into Lime.

Nº 3. *Stalactites*, or *Dropt-Stones*, which is a light soft Stone commonly of a white or grey Colour, therefore always calcareous, and will always burn into Lime. It seldom proves of another Nature.

31. Finally, there are Stones which, in the greatest common Fire, either do not change at all, or at least are never melted, nor reduced into Lime by being wet: Whence they are very properly called *Apyri*, or such whereon the Fire hath no Effect.

Nº 1. *Chalk* deserves the first Rank among these, as it suffers no Alteration, if pure, not even in the *Focus* of a Burning-glass. It is light, white, soft, and porous. It transmits Water through it, and ferments with all Acids, in which it also dissolves. It is not fat, but rough to the Touch.

Nº 2. The *chalky* and *impure Marles* come next: To their Class must be referred the *Terra Tripolitana*, or *Tripoly*, which is like Chalk, but lighter, and feels softer.

ter. It is found yellow, white, red, and grey; and hardens in the strongest Fire to such a Degree, as to give Sparkles with a Steel.

N^o 3. *Asbestus*, a Stone consisting of rigid and stringy Fibres wove together, and cutting each other across. It varies very much as to its Weight. It scarce changes in the greatest Fire, except that it commonly turns white, and becomes harder than before. There is a kind of very light *Asbestus*, called *Suber Montanum*, which melts into a black kind of Glass *.

N^o 4. *Amiantus*, or *Earth-Flax*, which is little different from the foregoing, except that its Fibres are pliant and parallel; so that the *Virtuosi* make Thread, Cloth, and Paper, with a certain kind of it. It sustains a moderate Fire without being altered: But when it is exposed to the greatest Fire, it either partly or wholly loses its Pliantness: This is chiefly true of that kind of *Amiantus*, which is friable between the Fingers, and is falsely called *Alumen plumosum*: For it hardens in Fire to such a Degree, as to strike Light with a Steel †.

N^o 5. *Ollaris* ‡, *Lebetum Lapis*, *Pot-Stone*^a, which feels exactly like hard Soap: It is most commonly somewhat transparent; soft, ponderous enough, and very easily carved with a Knife. In the Fire, it turns white, and hardens to such a Degree as not to be surpassed by Flints, and to strike a Light immediately. But it cleaves in the greatest Fire. A few kinds of Tobacco-pipe Clay belong to the same Class.

N^o 6. *Talc*, it is a Stone consisting of small Scales, lying one upon another; It has a soapy feel: It is sometimes tenacious; resists a great Fire, and suffers there no other Alteration, but its becoming more brittle.

N^o 7. *Mica*, Glimmer or Glist, it is of the foregoing kind; shining, and brighter, black, gold or silver colour'd; nor can it be conquered by either Fire or Water.

* A. Henckel. De Lapidum origine, p. 58. † Idem, ibid. pag. 55. ‡ Carol. Linnæi Systema Naturæ, Tab. I.

^a It may be so called, because in Switzerland they turn Pots and Kettles out of it, that will bear the Fire to boil Meat in them.

Many kinds of these Stones, which feel like Soap before they are burnt, become somewhat rough by the Force of Fire.

32. There are still many other kinds of Stones, whose Differences are infinite as to their Figure, Colour, Hardness, Transparency, and Weight. I shall forbear to enumerate them; my chief Purpose requiring, that I should only describe here the most common of them, and those in which the other Minerals most commonly lye hidden. Besides, there are many Sorts of Stones that are Mixtures of several others, which it is not our Business here to mention, as we treat only of those that are simple. As for the rest, whatever other Stones are found, besides these, may be referred to one of the hitherto mentioned Classes; though they possibly have other Characteristicks belonging to them in a more specifick Manner.

33. However, I by no means believe, that what I have hitherto said, is sufficient for a perfect Knowledge of all the Stones which Nature affords: For I have done only what I could, not what I would; and should any one say something better on the Subject, I would gladly lay hold of it. There is certainly such an infinite Combination of Forms and Proportions in the Mixture of Stones among themselves, that no Eye is capable, even with the Help of Instruments, to distinguish them accurately. The Figures, Colours, and other the like outward Qualities, are seldom constant, as they depend upon a Multitude of Causes, not belonging to the Matter of the Stone itself: So that he may easily be deceived, whom forms any Judgment or Distinction from them. That Method is better grounded, which makes the Trials in several Degrees of Fire, first in close Vessels perfectly clean, and able to resist Fire, and then in open Vessels, and in a Wind Furnace, or a Smith's Forge.

34. Who can deny that there are many *Genus's* and *Species* of simple Minerals, besides those already mentioned? It is not to be doubted, but that there are, in the Nature of Things, Salts, and perhaps Metals,

als, and Semi-Metals, different from those above-mentioned, nay perhaps Minerals that could not be referred to any of these Classes: Nor can we deny it, when we consider that Nitre, which, as far as we know, was a Secret to the Ancients, has been found out but a few Ages ago.

Coroll. As the Art of Assaying teaches the Nature and difference of simple Minerals, and the Mixture of those compounded, its Usefulness is evident for the compleating Natural History. Nor is it less useful and necessary in Metallurgy. For as no Man can pass any certain Judgment upon the Nature of Minerals, from the bare Inspection of them, he must for that purpose have Recourse to docimastical Experiments. Let us take, for an Example, some Lead Ore, of a yellowish green Colour, and mix'd with Crystals resembling Spar, shooting like Nitre, which, as far as I know, is found in one Place only. Let us suppose a Man to have seen Lead Ore, of all sorts, this very rare one excepted; the bare Inspection, the Figure, Colour, and Weight of it, will never make him find out, that this Ore is very rich in Lead; which any Man skilled in these Things will confess to be true of many others. *Ercker* speaks of Workers of Mines, who had, with no small Detriment, mistaken Ores of Tin for Ores of Iron *.

35. The Aim of docimastical Operation is twofold; *viz.* to know, *first*, what kind and what quantity of each Mineral is contained in the compounded Subject; *secondly*, what kind and how much may be extracted out of it, with some Benefit.

Scholion. *The Workers of Mines are often misled by the Assayers, who make their Trials in such a Method, and with such Additions, as can never be used in greater Operations, on account of the vast Expence and Trouble which attend them. For when the Operation is undertaken with that View, the Method of it ought to be such as can be imitated and pursued in larger Works, or in the*

* *Yid. Laz. Ercker's Probir. Buch. pag. 120.*

room thereof some other Method may be substituted equally beneficial.

CHAP. II.

Of Docimaistical Menstrua, and the Preparation of them.

36. **B**EFORE we treat of the Instruments and Vessels, and come to the Operations themselves, it is proper for us to shew the Nature of those Bodies, which are to be contained in these Vessels, directed and applied by these Instruments, and which shall act upon the Object of Assaying.

37. Those Bodies, which, being applied to others according to certain Rules, dissolve them so as to adhere themselves in a State of Division to the Particles of the Body dissolved, and cannot separate from them again of their own accord, are called *Menstrua*. These are chiefly divided into *dry*, and *moist*; which last are again subdivided many ways: But this being mentioned in all the Writings of the Chemists, we shall pass it by in Silence, as we only treat of one Part of Chemistry: For we need only to explain in a special Manner, the Operations belonging to our present Purpose, and to acquaint the Reader with the Preparations of them.

Of METALS and their Products considered as Menstrua.

Of LEAD.

38. See its Characteristicks, *Chap. I. § 9.* When Lead is exposed to a moderate Fire in an earthen Vessel, the Surface of it is immediately covered with a thin tenacious Skin of *Scoriae*, of different Colours: When the Fire is increased so as to render the Vessels quite red hot, this Skin melts a little, and is thrown to

to the Side of the Vessel, where it turns into Drops called *Litharge*. Then the Lead seems to boil and smoak, and small Drops resembling the first *Scoriae* are incessantly produced; that swim upon the Lead like Oyl and are continually thrown towards the first. If the Fire is kept at the same Degree, the whole Mass of Lead at last turns into *Litharge*.

39. If you put Copper into Lead thus smoaking, it causes a much brisker Ebullition, and the Copper as it were bursts, divides, and seems to become but one homogeneous Mass with the Lead, which Mass is brittle, and, when broken, its Surface, if there hath been added about half as much Copper, will have the Colour and Figure of a Piece of tempered Iron or Steel.

40. Gold and Silver likewise, melted with Lead, become brittle, and Gold especially turns pale, by the least Mixture of it.

41. Tin is melted with Lead, by a Fire not much greater than what would melt both severally: But so soon as the Fire is increased so as to make the Vessels turn red, the Tin immediately rises above the Lead, like little whitish dusty Hillocks; so that one unskilled in these Matters would be apt to think that Coals had fallen into the Metal: If they have been taken but a little while out of the Fire, they look like burning Coals. Tin thus calcined, when grown cold, has its Colour variegated with white, yellow and red.

42. Lead, so long as it keeps its metallick Form, can never join with Iron, though urged with ever so great a Fire.

43. Semi-Metals are easily melted with Lead by Fire, and a great Quantity of them deprives it of its Malleability.

44. This Metal must oftentimes be made into small Grains, that it may be mix'd with the others, and its exact Weight be more easily determined.

But this Commination is best made the dry way, in the following Manner, which is called Granulation. Put Lead in an iron Ladle, melt it on a gentle Fire;

so soon as it is perfectly liquid, pour it at once into a wooden Vessel having a wooden Cover, or some other Vessel in which a Fluid may be very strongly shaken, without however any danger of its running out. But let the Sides of the Vessel be well rubbed with Chalk or Wax; then let it be thoroughly shaken, so that the Lead, agitated within, may dash strongly against the Sides of the Vessel; nor do you cease this Motion, till it becomes solid: You will find the greater Part of the Lead, divided into very small porous Grains. Let then the Chalk that sticks to it be washed off; then sift the Grains, to make them equal, dry them, and keep them from the Dust in a clean Vessel, for the Uses hereafter to be explained.

Scholion I. *The Reason of doing thus is this. There are among Metals some, as Lead, Tin, and Brass, which, when ready to melt, are extremely brittle, like wetted Gravel. The Chalk wherewith the Inside is rubbed over, gives the Surface a vast resisting Force, and preserves it from burning. Now, if the melted Lead be shaken and dashed against the Sides of the Vessel in the Manner aforesaid, the Minute it begins to become solid, the Mass, at that Moment being of the utmost Brittleness, is shivered into a minute Dust, which can hardly be obtained any otherwise than by this manual Operation.*

Scholion II. *There are Cautions to be taken. First, Let the Lead not be melted by too great a Fire; for this occasions a thin Skin on the Surface, which though taken away is immediately succeeded by another, which, mixing with the Lead during the shaking, hinders very much the Success of the Operation, it being too tenacious. Secondly, Let the Lead be sufficiently fluid; lest the Mass, so soon as poured in, should wax cold before it might be broken to pieces.*

Corollary. It is then plain, that this Granulation cannot be made with such Metals, as are more tenacious in proportion as they are nearer being melted; such as Gold, Silver, &c.

45. Lead, and all its Products, turn into Glass by a great Fire (§ 9, and 38.)

46. This

46. This Glass or Litharge pounded together, and melted with vitrificable Stones, (§ 29), makes them turn into Glass with a much less Fire than they would have done by themselves. If you add a sufficient Quantity of Litharge, these Stones melt into a kind of Glass so very attenuated, that it insensibly perspires through the Vessels; nay, it melts the Vessels themselves, when they yield not a free Passage to it.

47. All Lime-Stones (§ 30), if used in the same Manner (§ 46.) and mix'd with Litharge, have the same Fate, but they require a much greater Quantity of Litharge, to acquire the same Degree of Fluidity, when melted.

48. Stones that keep unburnt in the Fire (§ 31.) are more difficult to be changed; and unless some mechanical Mixture is used, and a moderate Fire preserved a long while, the Litharge vanishes through the Vessels that contain it, before it has perfectly melted these Stones.

49. Among Metals, Litharge likewise facilitates the Fusion of Copper and Iron by Fire, but at the same Time it consumes a considerable Quantity of them, and runs itself with them into Glass, as is plain (§ 46.) from what has been said. But the Glass of Lead does not mix as much with these Metals before they are destroyed, as it does with the aforesaid Stones; but swims about and upon them.

50. Tin and its Calx (§ 10, 41.) is with great Difficulty vitrified by a Mixture of Litharge, for it, always separating from it, swims upon it. But, if it turns into Glass at last, it preserves a certain Clamminess, not to be taken away except by a considerable Addition of Litharge. The Vitrification of its Calx is in some Degree promoted by Copper: Which being added to, and melted together with it, makes it more easy to be conquered.

51. The melting of Gold and Silver is likewise hastened by Glass of Lead (as § 49.) and they lose nothing by it. However, if Gold and Silver are very frequently melted with Litharge, they at length prove

to have lost a Trifle of their Weight : Nor are they, for all that, destroyed of that Quantity, for it may, by a plain Separation, be extracted again out of the Litharge, and will then be found of the same Nature as before : As the Operations in our second Part will shew.

52. The melting of Semi-metals is also promoted by a Mixture of Litharge ; and then it happens with them as with less perfect Metals : Which is facilitated by an Addition of Iron.

53. Therefore it is self-evident of what great use this Litharge is in roasting refractory Ores of Gold, Silver, and Copper. For it melts any Stones and Earths whatsoever, with more Swiftness, than it turns Metals into Glass, provided every thing be equally and minutely mix'd. Then the Metal which is heavier goes down through the Glass, which is in a thin Fluxion, and gathers into a *Regulus*, upon which a few small earthy *Scoriae* are swimming. But there is always a Part of the Metal destroyed at the same Time : Or, if it is Gold or Silver, a small Quantity of it is detained in the *Scoriae*.

54. But, as the Litharge penetrates through any Vessels whatever, and, while melting, rises into a Scum, and thus easily overflows ; Assayers never use it alone, but communicate a Clamminess to it, and fix it by adding a certain proportionable Quantity of Flints, Sand, Clay, &c. for they take of Powder of calcined Flints, or of Sand one Part, of Litharge two Parts, which they mix very exactly by pounding them together ; to this they add Nitre or common Salt, that the whole may melt more easily ; they shut the Vessels, which must be thick and solid, with a small Cover cut close, lest the Coals which are to reduce the Litharge into Lead, should fall into it ; they leave it thus melted for above a Quarter of an Hour and more ; during which Operation they must be ever looking into the Ash-Hole of the Wind-Furnace, to examine whether the Crucible holds the Glass or no. For it most frequently happens, that it perspires through

through the Crucible like Water, and falls down in Drops into the Ash-hole: when you see this, you must immediately take the Vessels out of the Fire, if you are not willing to lose all. Having broken the Crucible, you most commonly find a small *Regulus* of Lead, reduced by the Fatness of the Salt, or of the impure Nitre: In the Middle is the Glass of Lead, which is to be separated and kept for use, the saline Cake which is at top must be thrown away.

55. If you use Clay or Potter's Earth, or the *Caput Mortuum* of Vitriol wash'd, you make likewise excellent Glass with Litharge; only you are to take care not to add too great a Quantity of these Things; for when Litharge is too much saturated, it cannot consume the Bodies to be separated from the Metals. The Glass likewise becomes useless, when Part of the Litharge runs through the Vessels. This Damage proceeds either from the Crucible's not being solid enough, or from the mechanical Mixture's having been neglected.

56. Moreover, it is to be noted concerning Lead, that its Vapour, if it touches even the best Gold, renders it brittle.

Of Tin.

57. See the Description of it (§ 10.) Tin easily melts with Silver, Gold, and Copper; but when they are melted with it in equal or less Quantity, it renders them extremely brittle; especially Silver, which becomes as brittle as Glass by the least Mixture of Tin. But if a much greater Quantity of it enters into metallick Masses, these still preserve some Pliantness; For instance, ten Parts of Tin and one Part of Copper melted together make a Mass more rigid than pure Tin, but which is still somewhat tractable: By this Artifice, they make Utensils of Tin that are much more durable. If you add to Copper ten Parts of Tin, and a little Brass or *Zink* together, this will produce a brittle and very sonorous Metal, fit for making of Bells and Cannons.

58. Lead is of all Metals that which acquires less Brittleness by being mix'd with Tin : Though it becomes somewhat more rigid.

59. Filings of Iron, or very thin *Lamine* of it, being presently made red in the Crucible, if you pour upon them the double Quantity of Tin, on a great Fire, they will turn into a brittle white *Regulus*, yielding quickly to the Attraction of the Load-Stone. And here you must have a very quick Fire, lest too great a Quantity of Tin should be consumed. In order to which, and for the quicker melting of the Iron, it will be proper to add a Quantity of Argol, that is the crude Tartar of Wine, and Glafs.

60. The Vapours of Tin are infinitely noxious to Silver, Gold, and Copper ; as they render them brittle : Nay, if you sprinkle ever so little Tin in the Fire where these Metals are to be put, the most ductile of them, being made red on such a Fire, becomes so very untractable, that the least Touch of a Hammer will make it split like Glafs. Therefore, if the smallest Quantity of Tin should happen to fall into the Fire ; the whole must be taken out of it with great Care, and the Fire be made once or twice stronger ; that whatever Part of Tin remains, may be entirely dissipated.

Of COPPER.

61. Copper, melts together with Silver and Gold, witnesses all our Coins and Utensils, and makes them harder ; whereas they could hardly otherwise be applied to any use in common Life, on account of their great Softness.

62. Copper put on the Fire with Iron, promotes the melting of the latter : However it becomes itself more rigid and more pale by this Mixture. But it will be proper, in order to make this melting more successful, to throw upon it as much Tartar and common Glafs, as would be necessary to cover the Surface of the whole Mass.

Of

Of GOLD and SILVER.

63. Gold and Silver mutually melt with one another, and are besides easily mix'd with Iron. As to their other Properties, I shall refer you back to what has already been said.

Of IRON.

64. See what was said before. However, it is observable that Iron must be extremely pure in these Mixtures; for if it contains too much *Sulphur*, the melting does not succeed so well; and the Iron gathers into a *Regulus* separated from the other Metals.

Of MERCURY.

65. *Mercury* mixes with Gold, Silver, Lead, Tin, Zink, and Bismuth; but not quite so easily with Copper. This Solution is called *Amalgamation*. But all these *Amalgama's* become white, and, when a great Quantity of Metal is dissolved in *Mercury*, they thicken into a kind of Paste. But the following Conditions are required, for the quick and good Success of these Mixtures.

First, That the Metal be comminuted, which may be done any way, provided there is no Alkali in the Operation; because this either retards, or totally hinders, the Action of the *Mercury*.

Secondly, That a mechanical Mixture be employed by grinding in a Mortar.

Thirdly, That the Heat be as great as the *Mercury* can bear without being dissipated.

Fourthly, That the Surface of the Metal be very clean, and above all free from Greasiness.

66. But there is a greater or less Quantity of the said Metals dissolved, according as the Conditions already mentioned are not wanting, and the Purity of the *Mercury* is greater or less.

67. However, you must take care, that a Part of the dissolved Metal be so perfectly attenuated by the *Mercury*, that it may insinuate through the Pores of a Filtre, as Salt dissolved in Water. However it is

but a very small Quantity that can be thus dissolved; a certain one cannot be universally determined, since it must be found out by a very gentle Distillation, in Experiments made on purpose. The other Part of the dissolved Metal runs freely with the *Mercury*; But if the *Amalgama* is strained through a Glove-leather Purse, the Metal is retained in it, imperfectly dissolved, together with about an equal Quantity of *Mercury* adhering.

68. Mercury has no Power on Iron and *Regulus* of Antimony; or, if it has any, it must be exerted by an Artifice which has been hitherto a Secret to us.

II. Of SEMI-METALS, considered as Menstrua.

Of ARSENICK.

69. Arsenick, the Description whereof was given (§ 17.) well pounded and mix'd together with several Earths, especially with such as are calcareous and not to be affected by the Fire, being exposed to the Fire, proves much more fixt than it is of itself.

70. If to the Mixture (§ 69.) is added a little *Tartar*, and it be then lightly moistened with Water, and pressed down with small Plates of Iron interposed every where, in a Vessel, able to resist the greatest Fire; and if finally, the Vessel being well closed with only a small Aperture left to it, is exposed for six or eight Hours, first to a moderate Fire encreased at last to the highest Degree, so that the Mass within may be melted; the whole proves a white brittle *Regulus* of Iron, not to be reduced to its former State, except by an open Fire, continued very long.

71. If Copper is managed in the same manner with Arsenick, it acquires the same Whiteness, and retains in good part its Malleability: Especially, if it is once or twice melted with *Tartar* and *Borax*, that the superfluous Arsenick still inherent may be dissipated.

72. Tin and Arsenick, mixt over the Fire, turn immediately to Ashes, the Part of the Arsenick adhering strongly enough to the Tin.

73. Lead

73. Lead mix'd with Arsenick is immediately and partly carried away, in the Form of a thick Smoak, the rest being a thin Glafs of a Saffron colour.

74. Silver is penetrated by Arsenick applied in the same (§ 70.) manner, and loses its Malleability; but it vanishes away by a great Fire, in the Form of Smoak.

75. Gold, penetrated by Arsenick, becomes infinitely brittle, it loses its Colour, and then being suddenly thrown in a great Fire, Part of it is sublimed.

Scholion. *Arsenick, on account of this Property, is called Sulphur rapax: Because, by its Action excited with Fire and Air, there is often a greater Quantity of Metals raised and sublimed in form of Flowers up the Furnaces, than is collected in the very melting Pots of the Furnaces themselves. However, the solid Matter thus sublimed is called Cadmia fornacum.*

76. Finally, *Arsenick* is attracted with a different Force by different Metals, and attracts them reciprocally. Of all Metals it absorbs *Iron* most greedily, and successively *Copper, Tin, Lead, and Silver*. Therefore all Metals may be freed of the Foulness of *Arsenick* by *Iron*, but not so well by *Scoriæ of Iron*, unless the Fusion be made in an open Fire: For then *Scoriæ* may be usefully employed, because, though they do not of themselves absorb the *Arsenick*, they nevertheless being reduced to *Iron*, act in the same Manner as *Iron* itself. Now we shall soon shew, that they may be reduced to it, by the means already mentioned.

Of ANTIMONY.

77. The *Regulus* (§ 16.) of *Antimony*, when melted by a great Fire, proves totally volatile. In the Fire, it bubbles almost like *Lead*, and dissolves into a kind of Glafs not very fix'd, while the rest vanishes into Smoak.

78. The same renders all Bodies hitherto known volatile, Gold on certain conditions excepted.

79. When pulverized not very fine, it turns into a *Calx* in a moderate melting Fire, which *Calx*, being melted by a great Fire, turns entirely into a kind of Glass, which is of a dark red Colour, half transparent, and sufficiently hard. This Glass has a greater Efficacy upon Bodies, than *Litharge* itself (§ 46.--52.) for it attenuates Stones of all kinds, dissolves them, and with a very strong open Fire carries them away with it in the Air.

80. If this Glass does not equally change all Metals, it turns them into *Scoria*, and makes them volatile, *Gold* alone excepted; Because it is thereby freed of all heterogeneous Matters, except of *Silver* and *Tin*, whose Separation is more difficult to be obtained that way; you may therefore with Reason call it the Wolf and Devourer not only of Metals, but of almost all Bodies.

81. However, this Action (§ 80.) of the reguline Part of *Antimony* is greatly augmented, if you use at first a strong Fire with Vessels well closed, or throw upon it any kind of Fat whatever: For by these means you hinder the *Regulus of Antimony* from evaporating immediately, and its Virtue to destroy Bodies is of longer Duration; so that at last every thing vanishes, and is consumed by a strong and open Fire.

However, the *Regulus of Antimony* unites as variously with different Metals, as was said (§ 76.) *Arsenick* did; for it greedily incorporates with *Iron*, and next with *Copper*, &c.

Coroll. Hence appears how near of kind *Regulus of Antimony* is to *Arsenick*: For the whole Difference seems to be, that *Arsenick* is fix'd in *Antimony* by a vitrifying Earth. Whence it happens that when *Antimony* is mix'd with Metals, it can hardly be consumed from thence by Ustulation only: Nay, when being exposed with them to the open Fire, it evaporates; it in the mean while destroys the metallick Particles, as soon as it renders them volatile.

Of BISMUTH.

83. *Bismuth* (§ 15.) causes the less fusible Metals to melt, by a much less Fire than they would, if they were to be melted single : It mixes easily with them all, and according to the greater or less Quantity of it added to them, it renders them more or less white, brittle, and Semi-metal-like.

84. But *Bismuth* being so easily destroyed, it is proper that the Mixture of it with Metals difficult to be melted, be made in close Vessels, that the Fire be incessantly increased, and the other Conditions fulfilled, which are mentioned (§ 59.)

85. It is very observable, that *Bismuth*, melted with *Lead*, *Tin*, or *Silver*, disposes them so, that, being afterwards amalgamated with *Mercury*, they are infinitely more attenuated, and pass through the Leather together with the *Mercury*, in much greater Quantity than they would if there was no *Bismuth* (§ 67.)

Of ZINK.

86. *Zink* (§ 14.) mixes easily with *Lead* and *Tin*, and, according to its Quantity, renders them less malleable.

87. He that is willing to melt *Zink* together with Metals not very fusible, must use the Methods prescribed (§ 59.)

88. When it is by Fusion mix'd with four Times the Quantity of Copper ; it becomes a brittle Metal, of a fine Gold-Colour, called *Prince Rupert's Metal*, *Prince's Metal*, or *Bath Metal*.

89. It is moreover observable, that *Zink* is very rapacious : Which Quality of it is not so easily corrected by an Addition of *Iron*, as is in the foregoing Semi-Metals. For, by the Help of a greater Fire and of Air, it sublimes all mix'd Metals ; so that they adhere to the Furnaces and Stoves in form of Flowers,
(which

(which then are called *Nil album vel griseum Pompholyx*.) Or go away together, in form of Sublimate, called *Tutty* or *Cadmia fornacum*, in German (*Offenbruch*) infinitely various in Colour, Weight, Figure, and Consistence.

Scholion. But the foregoing Semi-Metals produce likewise the same Flowers and Sublimates, though without the Assistance of Zink: On which Account the said Sublimate and Flowers are of various Kinds. However, wherever these are produced, they are always Indications of some thing of the Arsenical or the Semi-metallick Species. On the same Account they differ much from each other: For some of them adhere to the very Sides of the Furnaces, in spite of a great Fire; and some others prove incapable of resisting a less Degree of Fire, even in the highest Chimneys.

Of pure sulphureous or oily Bodies, considered as Menstrua.

90. Imperfect Metals, such as *Iron*, *Copper*, *Lead*, and *Tin*, change their Form, lose all their Malleability, and part of their Fusibility, by a long and strong Calcination, and of Consequence lose their metallick (§ 5.) Nature. Semi-Metals, Arsenick excepted, by a like Calcination, dissolve into *Calx*, which by a strong Fire (§ 8. Schol.) turn to *Scoria*, or become volatile.

91. If you add to these *Calxs* (§ 90.) a sulphurous (§ 24.) Body, without any vitriolick (§ 22.) Acid, and so fixt of its Nature as not to be dissolvable by any but a great Fire; the brittle *Scoria*, or the *Calx* is restored to its Pristine, either Metallick (§ 5. or Semi-metallick State (§ 13.); which Operation is called Reduction.

92. This reduced Metal or Semi-metal may, by repeating the Calcination, again be destroyed (§ 90.) and in the same Manner (§ 91.) be reduced to a like *Soria*, or a like *Calx*.

93. Hence it is plain, that the *Oleofum purum Principium*, or a pure oily Principle, enters into the Composition

position of Metals and Semi-Metals; which may be still more confirmed by an Addition of Nitre. For if the Nitre, which detonates with every sulphurous Matter, is cast upon Metals grown red hot in the Fire; these Metals, under a very evident Detonation, immediately change into *Calxs* and *Scoriæ*; because without Nitre they never undergo so sudden a Change, in the same Time and Degree of Fire.

94. But the Chemical *Analysis* shews us, that there is a sulphurous or oily Principle of this Kind (§ 24.) contained in every part of Vegetables and Animals; since a great Quantity of it may be extracted thence, by a strong Distillation.

95. However, it is observable, that *Calxs* and *Scoriæ* (§ 90, 91, 92, 93.) are never so far reduced by sulphurous or oily Matters, as to be by them restored to their former Quantity: Nay, there is always a part of them destroyed: Which Loss does likewise vary, according to the Diversity of the Metal or Semi-Metal employed, or to the Duration and Violence of the Fire, by which the Calcination has been made; according to the quicker or slower Reduction of the *Calx*, and to the greater or less Purity and Fixedness of the oily Matter itself, wherewith the Reduction is made.

Corollar. I. From these Things appears the Reason of the Extraction by Fire of the Metals, Iron, Copper, &c. out of their Marcasite. For, if they are laid in *Strata* together with Coals, and then urged by a very strong Fire, excited with a Pair of Bellows, their *Scoriæ* melting, running between the burning Coals, and extremely attenuated by the Fire, is impregnated with the oily Exhalation of the burning Coals, and thus reduced to a metallick Form.

Corollar. II. As the *Calxs* of Metals melt in the Fire, with much greater Difficulty than the Metals themselves, whose Destruction gave them Birth; the Reason is plain, why a much greater Fire is necessary to reduce Metals and Semi-Metals from their

Calxs

*Calx*s to their former State, than to melt the same after their Reduction.

Corollar. III. For the same Reason, the fatty Matters added to Metals in order to melt them, put them sooner in Fusion, than the same Degree of Fire could have done, without the immediate Touch of oily Bodies.

Corollar. IV. It is likewise evident, why Metals and Semi-Metals, that are destructible by a naked Fire, are much less destroyed, when they melt under the Dust of Coals, or some other phlogistick Body, than if they alone and naked sustained the Strength of the Fire.

Of SALTS, considered as MENSTRUUA.

Of fixed Alcaly, considered as a Menstruum.

96. See the Characteristicks of this Salt. *Boerb. Elem. Chem. T. I. p. 764.*

97. *Alcaline Salt* dissolves *Stones* and *Earths* of all Kinds, in a great Fire, especially those that vitrify: Which is the sooner effected, as the Mixture was more exactly made before. Then a Glass is produced, which is extreamly various, according to the Diversity, Transparency, Hardness, Weight, Colour, and Fusibility in the Fire, of the *Salt* and *Stones*.

98. Gold and Silver, by the Help of this Salt, cast only upon them, are easily melted, and lose nothing, provided both the Metals and Salt be perfectly pure. But if the *Calx*, Filings, &c. of these Metals, mixt with a greater Quantity of *Alcaline Salt*, melt in the Fire; the whole Metal does not sink to the Bottom, but a part of it is detained in the Salt swimming at Top. But when the *Earths* and *Salts* are mixt with them at the same Time, the *Lentor* or Softness by the Earth communicated to the Salt, and which no Fire can perfectly attenuate, causes the Quantity of Metal in them remaining to be considerable.

99. Iron,

99. Iron, Copper, Tin, and Semi-Metals, being melted with this *Salt* of Oil made very sharp, are more slowly consumed. Besides, *Alkali* promotes very much the melting by Fire of Iron, Copper, and the *Regulus of Antimony*; But not that of Tin, Lead, Bismuth, and Zink; as these melt easier than *Salt* itself.

100. Mercury resists *Alcaly* altogether, nor can it be mixt with it by any Method that is known. This therefore is to be entirely avoided in the Preparation of Metals from an *Amalgama* (§ 65).

101. What kind of fixt *Alkali*, whether mixt with pure oily Matter, or with mineral Sulphur, is to be preferred, we shall point out hereafter, when we treat of compound *Menstrua*, *Flux's Cements*, &c; having hitherto explained only the simpler Species of them.

102. But the fixt *Alkali*, being, as it were, a dry *Menstruum*, serves chiefly to reduce the *Calx* of Metals, that have been reduced by Acids. For Acids, adhering to Metals, and being driven away violently by a Fire carried to an excessive Degree; they hurry a considerable Quantity of them away with themselves: And if they are obliged, by adding more of the fixt *Alkali*, to pass first, whatever metallick Matter they carry with them is absorbed and fixt: that by this Means the *Calx* of Metals, made intirely volatile by *Acids*, especially by that of Sea-Salt, may be reduced without Loss: Which cannot be conveniently effected by adding other *Menstrua*.

103. There is hardly any Necessity here to mention the volatile *Alkali*; it being very seldom, if ever, necessary in assaying.

Of Acids, considered as Menstrua.

104. *Acids* are employed by Assayers, either the moist or the dry Way, and according to the several Methods used, produce different Effects. Among these Acids occur, 1st, The vegetable Acids, of which

which Wine-Vinegar is the only used. 2^{dly}, The fossile Acids, among which the natural Acid of Vitriol (§ 22.) has the first Rank; the Spirits produced with Nitre and Marine Salt by the Art of Chemistry, come next.

Of VINEGAR of Wine.

105. Vinegar of Wine, poured upon Earths and Stones of all Kinds, whether calcareous, raw, or burnt, dissolves them, with a violent Ebullition, into a Fluid, to appearance homogeneous. Likewise, it totally consumes those that are chalky, and not to be affected by Fire. But, among the vitrificable Stones, those which are called Flint, and all the others belonging to this Species, Sand, &c. do entirely resist Wine-Vinegar: But the rest, at least as to their vitrificable Parts, do not yield to its Power.

106. Among Metals, and Semi-Metals, Copper, Lead, and Zink, dissolve most readily with Vinegar. This corrodes Iron. It has no manner of Power on Silver, Gold, and Mercury. The others are more properly leisurely extracted than dissolved by Vinegar.

107. But these Dissolutions (§ 105 and § 106.) succeed quicker with Heat than in the Cold. The same is to be said of all the other following *Menstrual* Acids.

Of the Acid of VITRIOL.

108. Acid of Vitriol (§ 22.) has, with Earths and Stones, the same Virtue as Vinegar of Wine (§ 105.).

109. Among Metals and Semi-Metals it dissolves readily Zink, Iron, and Copper; and even Iron with an Exhalation smelling very unpleasant, to which Fire must not be suffered to approach, if the Dissolution is made in a Vessel that has a narrow Neck: For it takes Fire, and bursts the Vessels with great Violence.

110. *Silver, Mercury, Lead, and Tin,* are, in the Heat of the Ebullition, rather corroded than dissolved by this most concenrated Acid. Though some of them be at the same Time so far dissolved, as to pass through a Filtre, and may be washed with Water.

111. Gold is almost quite free from the Action of this Acid.

Of AQUA FORTIS.

112. Aqua Fortis and Spirit of Nitre are the same, and differ only by the Manner in which they are made. For the former is distilled with Vitriol and Colcothar, and the latter with Clay, Bole, Oil of Vitriol, Brick-dust, &c. But the generality of Assayers use Aqua Fortis, as being more easily prepared; because a Quantity of Vitriol, much less than the terrestrial Mixtures just mentioned, with less Fire also, expels the Spirit out of the same Quantity of Nitre. This Distillation of Aqua Fortis is made as follows.

113. You put Vitriol in an Earthen or Iron Pot: If you make a Fire under it, the Vitriol begins to melt and smoke; by increasing the Fire gradually, it thickens and assumes the Ash-colour. Let it be then stirred with a Twig just before it becomes solid, till it be perfectly dry: But let it be taken as yet boiling out of the Pot: For if it grows cold therein, it will stick to it so fast, that you will hardly be able to get it out. Pound in a most subtil Powder three Pounds Weight of this calcined Vitriol, and mix them perfectly with four Pounds of Nitre well dried, and pulverized extremely fine. Put all these together in a Cucurbite, a Retort, or an Iron Pot, and then put it in a Furnace, that shall be described in our Chapter of Utensils, where the rest of the Apparatus hereto belonging will likewise be explained.

Let then the Fire be made, at first not much greater than is necessary to make Water boil. When the

the Recipient begins to grow warm, then continue the same Degree of Fire, till all the *Pblegm* is expelled, which you will know from the Diminution of the Heat of the Recipient; then increase the Fire gradually, till you see a few slight yellowish Vapours rise. Keep up the same Fire for one or two Hours, and finally make it such as may warm the Vessels moderately; having continued it so for some Hours, let the Vessels wax cold, pour the Liquor, now emitting reddish Fumes, out of the Recipient into a Glass Vessel, having a Glass Stopple, and this Liquor thus prepared is your *Aqua Fortis*.

Scholion. I. In this Operation, you must always proportion the Duration of the several Degrees of your Fire, to the Quantity of the Matter to be distilled.

Scholion. II. Observe besides, that, for Security's Sake, you are to leave, in the Closure of the Recipient and Vessel which contains the Matter to be distilled, a Hole that may be stopt and opened with a Wooden Peg: For if you happen to exceed the just Degree of the Fire, especially when, in the beginning, the first and more subtiler Spirits, which are very elastick, come forth; the opening of this Hole may give them a Passage, lest the Vessels should burst, which would be vastly dangerous.

114. This Operation requires Nitre perfectly pure, that you may have true *Aqua Fortis*. Above all Things, you are to avoid the least Mixture of Marine Salt, for the Reason hereafter to be mentioned, when we treat of *Aqua Regia*. Mean while, as this Operation is very toilsome, and takes a very long time; I shall hereafter give a Method for making *Aqua Fortis* of the requisite Purity, and distilled out of a Nitre not even perfectly pure.

115. There are besides many other Ingredients, commonly used in the distilling of *Aqua Fortis*: viz. burnt Allum, Sand, and the like; which are here added, to hinder the Species, which may happen not to be sufficiently calcined, from foaming, and from breaking the Vessel with great Violence. But when these Species are sufficiently calcined, and dried up; then

then these Additions are perfectly needless, and by over-swelling the Mass to be distilled, requires Vessels of a much larger Size.

116. Nay, there are besides many other, partly needless and partly noxious, Ingredients used by Distillers of *Aqua Fortis*. Such are Blood-stones, un-slacked Lime, Plumose Allum, &c. all which it is nevertheless very proper not to use: For they are so far from having any good Effects, that they on the contrary yield a much worse and more expensive *Aqua Fortis*. This Water therefore must never be used in decimastical Operations, before it has been accurately tried. For indeed *Aqua Fortis* is but too often tainted with these heterogeneous Matters, the major Part of it consumes away, and it is frequently so fixt, that the strongest Fire is hardly able to take off the least Part of it. I would then here have nothing used besides calcined Vitriol, intimately mixt with Nitre; there being no need of any other.

117. However, Bole, Clay, and Brick-Dust, do likewise expel *Aqua Fortis* out of Nitre, which then is called *Spiritus Nitri*. But you must add four Times as much of these, in Proportion to the Nitre. Consequently, this Method is not so profitable as the former (§113). as it requires Vessels considerably larger.

118. As the extracted Spirits of Nitre are very difficultly condensated into Drops, especially in a sultry Summer's Heat, it will not be improper, on account of the calcined Ingredients, to pour into the Recipient one quarter-part of pure Water, and, what is still better, of Phlegm extracted out of *Aqua Fortis*: By which Artifice the Spirits will be much easier received.

119. *Aqua Fortis* dissolves and corrodes all gritty Stones, and the several Kinds of those that are vitrifiable and not consumed by Fire; but it has no Power on *Flints*, nor of course on *Sand*, as this consists of minute Stones of the same Kind.

120. It besides dissolves *Iron, Copper, Lead, Silver, Mercury, Regulus of Antimony, Bismuth* and *Zink*; *Tin* imperfectly; *Gold* not at all.

121 Common *Aqua Fortis*, when poured upon *Silver*, most generally grows troubled, in the beginning of the Dissolution; and a little after it is perfect, a Precipitation of a whitish Powder is made. If this Powder, taken by itself, melts in the Fire with Pot-ashes, you find at the Bottom of the Vessel a *Regulus of Silver* collected. This sometimes melts with Difficulty on the Fire, and has all the Characteristicks of *Calx of Silver* precipitated from *Aqua Fortis* by Oil of *Vitriol*. This certainly happens, because the *Aqua Fortis* has been extracted by too great and too long a Fire, or because too great a Quantity of calcined *Vitriol* has been used, or, in short, because the mutual Mixture of the *Vitriol* and *Nitre* has not been rightly made: For in these Cases, there appear, when the Distillation draws at an end, opaque, milky, vitriolick Fumes in the Recipient: Which *Phenomenon* sufficiently evidences the Cause of the aforesaid Precipitation. The abovementioned *Calx* very seldom proves Fluid in the Fire; it afterwards turns into *Horn-Silver*, and shews that the impure *Nitre* bought for the Distillation of the *Aqua Fortis* was intermixed with marine Salt.

122. But as the Dissolution of *Silver*, especially that by which *Gold* is separated from *Silver* with *Aqua Fortis*, is considerably hindered and made uncertain by this Kind of Precipitation (§ 121.); that Part of Oil of *Vitriol*, and of Spirit of Salt which spoils the *Aqua Fortis*, must be separated: Which is done in the following Manner. They pour one 30th or 40th Part of the *Aqua Fortis* to be purified, into a small Cucurbite, and over a gentle Fire they dissolve in it *Silver*, in such a Quantity as may fully saturate the *Aqua Fortis*. If in the beginning of the Dissolution the troubled *Aqua Fortis* looks milky, it is judged to want to be purified: Then they pass through a Filtre the warm Dissolution, which being clear they pour

pour drop by drop into the rest of the *Aqua Fortis* that is to be purified: This will become milky as before; they continue to instil the *Aqua Fortis*, till the dropping in of the smallest Drop doth not at all disturb it or render it milky: Then they let it rest for some Hours, that the precipitated *Calx* may subside; which done, they again let a Drop fall, and repeat it constantly, till at last the milky Cloud is no longer produced by the Falling of the Drop. Finally, they decant the pure and limpid *Aqua Fortis*, from the *Calx* which subsided at the Bottom; or they strain it gently through a fourfold filtering Paper, which ought to be small, lest it should break, by being overloaded with too much of the *Aqua Fortis*. The remaining *Calx* is such as was mentioned (§ 121.) but the *Aqua Fortis* is perfectly purified.

Scholion. Some are used to employ common Silver mixed with Copper, nay Copper itself, for the precipitating of the Spirit of marine or vitriolick Salt from *Aqua Fortis*: But this does not at all succeed, when Spirit of marine Salt is to be precipitated, because this being mixed with *Aqua Fortis* dissolves Copper perfectly. The Oil of Vitriol is indeed driven out of *Aqua Fortis*, by means of the Copper, in form of a whitish Dust; but not so perfectly as by Silver. Otherwise, it appears in this Operation that the precipitating Body adheres to that to be precipitated, and sinks to the Bottom together with it.

123. The best *Aqua Fortis* is often tinged with a greenish Colour: Which happens, if *Aqua Fortis* having been exposed for some Days to the open Air, and thus deprived of its fuming red Spirit, you pour upon it some fresh strong *Aqua Fortis* still emitting its Fumes; or if *Aqua Fortis* is diluted with Water. But that you may be certain that this Colour does not proceed from Copper, pour a little of the Liquor into a small Cucurbite, and add to it as much of an alkaline Dissolution or Spirit, as is sufficient to saturate the Acid: Then, if there is ever so little Copper, the Colour becomes of a very dark Azure, with a cloudy Precipitation; because the *Nitre* has been thereby

regenerated, which does not dissolve *Copper* so much as *Aqua Fortis* does: But if there is no *Copper*, the Colour vanishes entirely.

124. *Aqua Fortis* thus prepared (§ 113. and 117.) and corrected (§ 122.) must be concentrated to a certain Degree: For if it is too weak, it either retards the Dissolution, or often does not even affect the *Silver*. If, on the contrary, it is too strong, it vanishes into Fumes, which rush violently out of the Vessels, though sufficiently deep, hurrying part of the *Silver* along with them: But if there is any thing of *Gold* in the *Silver*, it is corroded into a *Dust*, the perfect Collection of which is afterwards very difficult. The first Fault is remedied, by pouring the *Aqua Fortis* into a deeper Cucurbite, and by abstracting Phlegm out of it, over a gentle Fire, till you see yellowish Fumes appear. But, to find out whether it is too strong, you are to use the following Method. Melt together one Part of *Gold* and Four Parts of *Silver*; of which make a Plate, which you are to cut into three or more Parts; roll up each Part, that it may more conveniently be introduced into a small Cucurbite: When rolled up, and slightly heated at the Fire, put this small Plate into the said Cucurbite, pour upon it *Aqua Fortis*, about the Triple of the Weight of the Metal, and put it on a gentle Fire: If then the *Silver* is eroded from the *Gold*, so that the *Gold* remaining retains the very same Figure of the Plate rolled up, and there appears no reddish *Dust* at the Bottom of the Vessel, then the *Aqua Fortis* has its proper Degree of Strength: But if the Dissolution has been made with so much Violence, that the Powder of the *Gold* was eroded, or the Plate almost broken, the *Aqua Fortis* is too strong. You must then, in this Case, dilute it with one tenth or eighth Part of pure Water, or rather of weaker *Aqua Fortis*, if you have it at hand, or of the Phlegm that was drawn from it: Which done, you must repeat the Trial of the Dissolution of a like small Plate, several Times over, till the *Silver* be dissolved without the
least

least Diminution in the *Gold*, whereby you may be sure of the requisite Degree of Strength in your *Aqua Fortis*.

125. *Aqua Fortis* is excellent, when it comes again after having been by Fire expelled out of dissolved Metal; because it may be almost entirely fetched out of it by Distillation. In order to this, you introduce into a middle-siz'd Glass-cucurbite, adapted to an Alembick, with an Hole in it, one Pound or one half Pound of the same Dissolution, and distil it in the Manner hereafter described in the Article of Utenfils, into a large Recipient; that the Drops may fall one after another at the Interval of some Seconds: When the Phlegm of what remains shall be drawn off to some Ounces; let a like Quantity of a fresh Dissolution, gently warmed, be put a-new into the Cucurbite, and be drawn off again; and let the pouring on of the fresh Dissolution be reiterated in the same Manner, till it is all grown thick. This must be done in a small Cucurbite, several Times over; lest a large Vessel, being over-charged with too great a Quantity of the Dissolution, should burst all of a sudden, and the *Aqua Fortis* and Metal be lost at once. When, after the extracting of all the Phlegm, yellowish Fumes begin to appear by increasing the Fire a little, let a Drachm or half a Drachm of Suet be added, lest the remaining Metal, being dried up, should so strongly adhere to the Sides of the Vessel, as that it could not be taken off: And when at last the Mass shall be quite dry, let it be put on the Fire, till it becomes red hot. The *Calx* of Metal, which remains at the Bottom of the Cucurbite, must be collected, and melted with Pot-ashes.

Of Spirit of common SALT.

126. Spirit may be extracted out of *common Salt* (§ 20.) after the same Manner (§ 113. and 117.), as it is out of *Nitre*: However, the Distillation of it requires a Fire much stronger, and much longer conti-

nued, than that of *Spirit of Nitre*. It comes out in the Form of small whitish light Clouds, which coagulate into a yellowish green Liquor. But this *Spirit* may be much more conveniently produced with *Oil of Vitriol*; by pouring one part of this *Oil*, diluted with an equal Quantity of Water, upon two Parts of *common Salt*: and then you make the Distillation out of Glass-Vessels, in a Sand-Bath. Spirit thus drawn, more diluted, and then distilled by a gentle Fire in a Cucurbite, from a Quantity of the purest *Sea Salt*, in order to absorb the Portion of *Oil of Vitriol*, which may happen to adhere, and then dephlegmated and rectified; I say, such Spirit must be looked upon as the best *Spirit of Salt*.

127. *Spirit of Salt* dissolves *Iron* into a yellowish green Liquor, and *Copper* into one of a deep yellow Colour. *Tin* dissolves in this Spirit with Violence and much Noise, in great Plenty, and becomes a thick, transparent Fluid. *Lead* dissolves in it likewise; but after it has rested a while, there is always something of a white Dust that sinks to the Bottom. *Silver*, provided it be very pure, does not dissolve in *Spirit of Salt*; but if it contains ever so little *Copper*, for it seldom is altogether free from it, its Surface is in a Manner corroded by the Acid of *Salt*, and its Colour sullyed. The best *Spirit of Salt* prepared with *Oil of Vitriol*, and rectified (§ 126.), being poured upon *Gold* does not influence it in the least. It dissolves *Mercury* into a limpid Liquor. When more diluted with Water, it does not dissolve *Regulus of Antimony*: But this being dissolved in the most concentrated *Spirit of Salt*, if you add Water to it, or only expose it to the moist Air, you reduce it again to a white Dust. *Zink* dissolves immediately in *Spirit of Salt*.

Of AQUA REGIS.

128. When the Spirits of *Nitre* (§ 113.) and of *Salt* (§ 126.) are mix'd together, this Mixture is cal-

led *Aqua Regis*. To have it excellent, put in a Glass-Retort *Aqua Fortis* of the best kind, well proved, and of the requisite Strength (§ 122, 124) add to it half the Quantity of common Salt, perfectly dry, and pulverized; and in a Sand-Bath force up the Spirits, first by a slow, and finally by a strong Distillation. Or if you put into *Aqua Fortis* one quarter Part of *Salt Ammoniac*, or of *Spirit of Salt* (§ 126); it immediately assumes a yellow Colour, and emits abundantly the white Vapours of the *Spirits of Salt*, which soon produces true *Aqua Regis*. However, you are to take Care, in this second Method, that the Vessel containing the Mixture be not presently shut up close: For in that case it would burst. Besides, this Mixture must be made under the Chimney, lest the suffocating Spirits should spread all over, and fill the Laboratory.

129. *Aqua Regis*, dissolves perfectly *Iron*, *Copper*, *Tin*, *Gold*, *Mercury*, *Regulus of Antimony*, *Bismuth*, and *Zink*. It even dissolves *Lead* more than *Spirit of Salt* does; however, it becomes somewhat troubled in the Operation. If it has its requisite Degree of Strength, it does not dissolve *Silver*: But if you have put in the Mixture a Quantity of *Salt Ammoniac*, or of *Marine Salt*, or of *Spirit of common Salt*, not sufficient, it then corrodes *Silver*, nay, it even dissolves it in part, this *Aqua Regis* being imperfect.

Coroll. The Reason is then self-evident, why in the Separation of *Silver* and *Gold* by *Aqua Regis*, it is better to use a Quantity of *Spirit of Salt*, or of *Marine Salt*, or of *Salt Ammoniac*, exceeding, than one short of the right Measure. Nor is it less evident thence, why an exact Separation of *Silver* and *Gold* is better effected with *Aqua Fortis* than with *Aqua Regis*; as the former never corrodes *Gold*, whereas the latter corrodes *Silver* frequently.

Of NEUTRAL SALTS, considered as Menstrua.

130. The *Neutral Salts* here chiefly used, are *Borax*, *fel Vitri*, that is, the Scum of Glass called by the *Germans Glass-gall*, in *English Sandiver*, *Nitre*, common Salt, and Salt *Ammoniack*.

Of BORAX.

131 *Borax*, or *Chrysecolla*, (*Cold-Sodder*) is a Salt very difficult to be dissolved in Water. It is white, somewhat transparent, consisting of octoëdral Crystals; having a sweetish Flavour at first, and in the End an alkaline urinous After-taste. *Borax* exposed to the Fire, is raised into Spume with a hissing Noise; when at last the Vessel grows red hot, it becomes a thin Fluid, and then growing cold it looks like a very fine Glass: However it is at any time dissoluble in Water, though with great Difficulty.

Scholion. *Borax* being so apt to foam and swell on the Fire, it is very proper to melt it before it is used; lest it should raise over the Vessels.

132. All Earths and Stones, well mix'd and pounded together with *Borax*, dissolve into Glass of different Species.

133. *Borax* forwards very much the melting of Metals difficult to be put in Fusion; as are *Gold*, *Silver*, *Copper*, *Iron*, *Regulus of Antimony*, and diminishes them very little. When, therefore, Metals are dispersed, or divided into very minute Parts, retaining however their metallick Form, and are then to be again reduced into one single Mass by Fire, *Borax* is of very great Use. Dirt and Ashes, though in ever so small a Quantity, will certainly hinder small Particles of *Gold* and *Silver* from melting easily into one single Mass. But if they are so disposed by a very strong Fire, as to melt into *Regulus*, a great Part of the Metal will always adhere to the slightest Filthiness that is flung away. But the viler kinds of Metals not only

undergo the above-mentioned Accidents; but their Surfaces being so far encreased; *Copper* and *Iron* turn entirely into *Scoriae* and are destroyed, and *Tin* and *Lead* are so in great Part. It is therefore very detrimental when these viler Metals are mix'd in ever so small a Quantity with *Gold* and *Silver*. For in the melting there come upon the Surfaces light *Scoriae*, in which the *Gold* and *Silver* is retained as in Sponges, and is hindered from running into the *Regulus*. To remove these Inconveniences, *Borax* is added, because, as it helps the melting of Metals, and of all Bodies by Fire, its bringing the whole Mass to a quick Fusion, causes the Metals to sink to the Bottom without Loss, and vitrifies the lightest *Scoriae*, throwing them on the Surface. Which is true of both the nobler and the viler Metals, but of *Copper* and *Iron* especially. Besides, *Borax*, by covering the Surface of Metal tortured in the Fire, as if it were with a kind of very thin *Glass*, defends it against the combined Force of the Fire and Air, which is very destructive of imperfect Metals especially; besides, that it also causes Metals to melt in a much less Fire.

134. It is likewise expedient to rub with *Borax* the Inside of the Crucibles in which the more precious Metals are to be melted: For they, by that Means, are totally covered with a thin vitreous Crust, when in Fusion, and the small Cavities which never fail to render the Inside of even the best Crucibles, uneven, are filled up: So that the Metal may be poured out all very neatly. Therefore, it is a chief Point never to neglect this Particular, when any little Mass of *Gold* or *Silver* is to be melted a second Time.

135. Observe however, that, if you melt *Gold* with *Borax*, you must add to it a little *Nitre*, or *Salt Ammoniac*, but not both together; because they would make a Detonation. For *Borax* alone makes *Gold* pale; but it recovers its Colour again, by means of *Nitre*, or of *Salt Ammoniac*.

136. *Borax*, on account of the above-mentioned Quality (§ 133.) is classed, though improperly, among

mong reducing Bodies, that is, among those which restore Metals, howsoever destroyed, to their metallick Form: For it reduces into one Mass of *Regulus*, not the destroyed Metals, but only the scattered Particles of them.

137. There are other neutral *Salts*, used for the promoting the Fusion of Metals: But they are seldom alone, and almost always mixed with Bodies of the reducing Kind only, of which we shall speak soon. For these alone almost always diminish something from the grosser Metals in Fire, or even change them altogether. Of this Kind are *common Salt*, *Sandiver* and *Nitre*. However, of these *Nitre* is most to be avoided: It is true, it promotes very well the melting of *Gold* and *Silver*; but as it, on the contrary, causes a Detonation with the sulphurous Part of the coarse Metals, which is not so intimately mixed, it changes them into Calxs, most commonly very difficult to be melted; which may be easily experienced in *Copper*, *Iron*, *Lead*, and *Tin*, mixed with an equal Quantity of *Nitre*, and thrown into a red hot Crucible. *Salt Ammoniack* is also now and then used by Assayers: Though its Defect may be easily supplied, sometimes with *common Salt*, sometimes with *Nitre*. For it seldom is used, except in the two Cases above-mentioned (§ 128. and 135.) viz. For the making of *Aqua Regis*, or for the colouring of *Gold*: And the former may be very well obtained with *common Salt*, and the latter with *Nitre*. For which same Reason, we have not mentioned *Salt Ammoniac* in our first Chapter.

Of SULPHUR, considered as a Menstruum,

138. Here we do not understand by *Sulphur* any inflammable Matter whatever (§ 24); but that Matter only which is mixed with the Acid of *Vitriol*. Such is *common fossile Brimstone*, which, in regard to the Acid mixed with it, has quite other Qualities, than an unmixed oily Principle.

139. The

139. The purest *Gold*, when melted with *Brimstone*, remains perfectly the same as before; it lets the *Sulphur* burn very freely, remaining itself at the same Time entire, provided it was very well cleansed before.

140. *Silver*, when it begins to grow red hot in the Crucible, melts immediately by adding *Brimstone*, which of course renders it more speedily fluid. When poured out, it proves a Mass that cuts very easily, very malleable, of the Colour and Consistence of *Lead*. However, this Mass, being a second Time exposed to a very great and long lasting Fire, is again freed from the *Sulphur*, which is then dissipated; and then it germinates into a kind of woolly Substance in case the Fire be slackened towards the End.

141. *Tin* granulated, and stratified with an equal or a double Quantity of *Brimstone*, deflagrates in the Fire as if *Nitre* had been added, and leaves the fluid Mass, which becomes solid and consistent, while it is yet red in the Fire: Whence it is plain, that the Fusion of *Tin* is retarded by *Sulphur*. The remaining *Regulus*, under the Hammer, is very brittle, much like a Semi-Metal, and of the Colour of *Lead*. But the Part of the *Tin* thus turned into *Scoriæ*, looks like Ashes and Dust at Top, but darker coloured and cleaner within. The whole Mass of the *Tin* will turn into the like *Scoriæ*, by continuing to burn it with fresh Additions of *Brimstone*.

142. *Lead* melted with *Brimstone*, after the Deflagration, turns into a Mass hardly fusible by a great Fire, friable, consisting of very bright Particles, and with which the Crucible is seen to be wholly incrustated.

143. *Copper* made into Strata with an equal Quantity of *Brimstone*, melts immediately in the Fire, and turns into a black brittle Mass. The same thing happens when you pour *Brimstone* upon *Copper* thoroughly red hot.

144. The

144. The very same Thing happens to *Iron*, which, being taken red hot out of the Fire, and rubbed with *Sulphur*, melts immediately into a spongy Dross. It quits this *Sulphur* with great difficulty, but melts very easily with it: So that there is no Metal or Semi-Metal that is so friendly to *Sulphur* as *Iron*.

145. *Regulus of Antimony* being well pulverised, mixed with *Sulphur*, melted, and stirred with a Hook, turns into *crude Antimony*, the Fusion of which is likewise promoted by *Brimstone*. However, it is more difficult than any of the foregoing to mix with *Brimstone*.

146. The same happens to *Bismuth* melted with *Brimstone* over the Fire, as doth *Regulus of Antimony* (§ 145): Which however is a little flower. Thence a Mass is produced, like *Antimony*, of a faint grey Colour, consisting of minute and very bright Needles [*Spiculi*] cutting each other across, and extremely brittle.

147. *Zink* melted with *Brimstone*, mixes with it not very easily; but if remaining long in a moderate Fire, it is covered over with *Sulphur* poured at several Times upon it, and continually stirred with a Poker, this at last produces a very brittle, dark-coloured, shining Substance.

Coroll. 1. Therefore, *Iron* being very greedy of *Sulphur*, all the other Metals and Semi-Metals may be freed of *Sulphur* by it.

Coroll. 2. A very small Quantity of *Iron*, a greater Quantity of *Copper*, and a considerable deal of *Lead* and *Tin*, are necessary to absorb the same Quantity of *Sulphur*.

Coroll. 3. The reguline Part of *Antimony* is precipitated from *Sulphur*, by *Iron*, *Copper*, *Lead*, *Tin*, and *Silver*.

Coroll. 4. The *Scoriæ* swimming upon the *Regulus of Antimony* made by the abovesaid five Metals (Coroll. 3.) are more or less fusible, according as these Metals melt more or less easily with *Sulphur* in the Fire: For the *Scoriæ of Regulus of Antimony* are nothing but *Sulphur of Antimony* mixed with precipitating Metals.

tals. Therefore, the Dross of *Silver* is very easy, that of *Tin*, *Copper*, and *Iron* more difficult, and that of *Lead* the most difficult of all, to be melted.

148. If you throw into a Crucible red hot on the Fire, white *artificial Arsenick*, mixed with one tenth Part of *Brimstone*, and cover it immediately with a *Tin*; and then pour it out after it has been one or two Minutes in Fusion, it becomes a solid brittle Body, of a Citron Colour; but if you melt it in the same Manner with a fifth Part of *Brimstone*, the Mass, when grown cold, assumes the red Colour; if at last you melt or sublimate *Arsenick* and *Sulphur* together, in an equal Quantity, it produces a fine red transparent Mass, which is called *Rubinus Arsenicalis*, *Sulphur Auratum*, the Arsenical Ruby, Sulphur of Gold.

149. *Brimstone*, melted with half the Quantity of fixed *Alkali* (§ 96). turns into *Hepar Sulphuris*, Liver of Sulphur, so called from its being of a Liver Colour; which, on account of the *alkaline Salt* it contains, makes all *Earths* and *Stones* melt soon in the Fire. When melted with any Metal whatever, it presently makes it run, and renders it brittle, no longer like a Metal or Semi-Metal, and makes it dissolvable by Water: This is so general, that even *Gold* and *Silver* are not excepted. Therefore, there are many Cautions to be used in the roasting of *Oars* by different Fusions.

150. A like *Hepar* (§ 149.) will be produced with vitriolate Tartar with *Sandiver* and other neutral fixed *Salts*, containing the vitriolick Acid, if, when they are red or in Fusion in the Fire, you add to them Coal-dust, or any other more fixt Phlogist.

151. The *Hepar Sulphuris* ^a is not so strong, when made with fixed *Nitre* made with Coals, or with *Alkali* composed of *Tartar* and *Nitre*, nor with neutral *Salts* with an addition of *Sulphur*, already containing the vitriolick Acid.

^a Frid. Hoffmanni Observ. Physico Chemi.

Of CEMENTS.

152. We have already declared (§ 104, and 129.) what were the Effects upon Metals and Semi-Metals of acid *Menstrua*, condensed in a fluid Form, by a Heat not greater than that of the Fire which makes them ebulliate. It now remains, that we should examine what are the Effects of the self-same *Menstrua* urged with the Degree of Fire which makes them red-hot, upon the Bodies aforesaid.

153. But, as the acid *Salts* condensed into Liquors (§ 105, 108, 113, 126, 128.) cannot bear to be made red hot, and are resolved by a much less Fire, into Vapours which cannot be restrained; this requires another manual Operation: For the Acid of *Vinegar* cannot be extracted out of the Crystals of *Verdigrease*, nor the Spirits of *Nitre* and *Salts* be extracted out of them, by terrestrial Additions, or by *Vitriol* (§ 113, 126); nor in short the Acid of *Vitriol* itself be fetched out of its metallick or terrestrial Matrix, without the Action of a very strong Fire. Therefore, you are to proceed in such a Manner, that the Bodies to be changed by these acid Spirits, be in the same Vessel wherein the said Spirits are produced, and, when made red hot therein, be surrounded on every Side with the agitated Vapours of the same Spirits. This is easily obtained, if you put the said Bodies among the Matter itself which is to emit the acid Spirits, after having moistened it lightly, and pressed it; and then expose them together to the Fire. This Operation is then called *Cementation*; and the dry *Species*, which melt the acid *Menstrua*, and are commonly used for this Operation are called *Cements*.

154. The Proportion of the Additions used in making the *Cements*, is the same as in the Distillation of acid Spirits (§ 113, and 126). But *common Salt* and *Nitre* being the melting *Menstrua* of Metals (§ 137; and *Vitriol* becoming extremely hard, by the
same

same Fire which is proper to be used in Cementations, that is, not a very strong one; on this Account, they use a Quantity of *Brick-dust*, *Colcothar*, &c. three or four times greater; lest the *Salts* happening to melt, by employing a Fire a little stronger, they should at the same Time put the Metals in Fusion, and above all *Gold* and *Silver*: For this is the Method of preventing the melting of *Salts*; or if they melt, you at least hinder them by that Means from running together, and from hardening to such a Degree, as that the Mass may not be pulled asunder, and the interposed Metal be separated, but with difficulty. For the same Reason, it is not proper here to use *Bole* alone, as an additional Help, because it hardens like a *Stone* in the Fire.

155. But, that the Spirits which are driven out (§ 153, 154.) of the Matter of the *Cement*, may act the longer and with greater Force; the Vessels, in which the Cementation is made, must be closed, the Closures being stopped with Clay, though not altogether without vent. By this Means the Spirits are beaten back, and yet not so absolutely confined, as not to be able, when the Fire is increased, to make their way through the Closures of the Vessels; which vent being not given them, the Vessels would infallibly burst.

156. Among Metals, *Copper*, *Iron*, *Lead*, *Tin*, and all Semi-Metals, being committed to any of the above-mentioned (§ 153, 154.) *Cements*, are totally corroded in a few Hours: Which will be the sooner done, if they are intermixed with the *Cement*, in form of *Lamina's*, or of Granulation.

157. Thus it is that *Silver* is immediately consumed by the several Species of *Spirit of Nitre*: Nay, *Spirit of Salt* consumes *Silver*, when used in this Manner, which otherwise does not corrode it, when it has the Form of a fluid Body. Nor does *Silver* resist the Vapours of *Vitriol* in a Cementation. Nay, the *Vinegar* of Vegetables itself, concentrated in the Crystals of *Verdigrease*, and mixed with terrestrial Bodies,

when used as a *Cement*, takes likewise something from *Silver*. But *Gold* remains untouched, in all the afore-said *Cements*. The other Metals, and all the Semi-Metals, whenever they are intermixed with *Gold* (if this be granulated, or reduced into *Lamina's*) are eroded from it by *Cementation*; this however is somewhat more difficult for *Silver*; but *Copper*, when mixed with *Gold* in greater Quantity, is consumed pretty soon: Nevertheless, a small Part of it remaining in the *Gold*, is so strongly defended by the latter, that it is a difficult Matter to separate them perfectly by *Cementation*.

158. The several Compositions and Effects of *Cements*, shall be described in the following Part, when we come to the Operations to be made with *Gold*.

Of the SIMPLER and REDUCTIVE FLUXES.

159. Whatever causes a Body, hardly or not at all fusible by Fire, to melt, is called a *Flux*.

160. But, what Species of Bodies have that (§ 159) Faculty which causes them to be called *Fluxes*, you are to see (§ 46, and follow, 97, &c. 130, &c.) where we treated of the Glass of *Lead*, and of fixed and neutral alkaline *Salts*. Assayers use them, when they want to examine Minerals in a small Quantity: This causes them to be called *Sales Fusorii*. But when a greater Quantity of Minerals is to be worked upon, it is seldom possible to use *Fluxes* of this Kind with Benefit, because they are very expensive. Then, instead of the above-mentioned *Salts*, they use such *Stones* as are vitrifiable by a gentle Fire; or the *Scoriae* made of the same *Stones* when melted, which serves this Purpose still better: For the more often these *Stones* have been exposed to the Fire, the more easily they are put in Fusion: The Reason of which seems to be the alkaline *Salt*, proceeding from the Fewel of the Fire, and adherent to the said *Scoriae* (§ 97). Therefore, these Things being in large Quantities added to Ores, in great Operations, they

cause the said Ores to melt, which are otherwise rendered refractory by the calcareous and incombustible *Stones* and *Earths* mixed with them: Which, however, is not so easily obtained with the said *Scoriae*, as by Means of the above-mentioned Glass of *Lead* and *Salt*. But the great Price of these hinders their being frequently used.

161. We have already said (§ 51, 98, 133, and 137.) how useful these *Salts* (§ 159, 160.) were, for the melting of *Gold* and *Silver*, and of their *Calxs*. But when, in the Fusion itself, *Gold* and *Silver* are to be purged of other Metals and Semi-Metals, then it is proper to use *Nitre* only, or at most *Nitre* together with other *Salts*. For Semi-Metals, and the four less perfect Metals, are destroyed (§ 137.) by *Nitre*; in which Case *Nitre*, by its Detonation with their *Sulphurs*, is in part alkalized, and, by help of a gentle Fire, turns the *Calxs* proceeding from these Metals, into a vitrious and much attenuated *Scoria*.

Coroll. Thence the Reason is plain, why *Gold* and *Silver*, made brittle, are readily restored to their Malleability by *Nitre*: For Semi-Metals, and among Metals *Lead* and *Tin* most of all, communicate this Fault to *Gold* and *Silver*: But being changed by *Nitre* in the Manner aforesaid (§ 161.) they are in a simple Fusion again rejected by *Gold* and *Silver*: So that they can no longer mix with these Metals, unless some Reduction is made. However, there is no other Body that can, by mixing with *Silver* and *Gold*, render them brittle, unless crude *Charcoals*, happening to fall into the Vessel wherein *Gold* and *Silver* are melted, should impregnate it with something arsenical; there being some *Arsenick* contained in *Coals* of this Kind, as is demonstrated by *Stahl* and *Hoffman*.

162. The most imperfect Metals and the Semi-Metals melt more easily, by adding *Salts* (§ 159, 160.) to them, than they do of themselves. However, they always lose a great deal of their Substance by this means, which happens especially with regard to *Copper* and *Iron*. To mend this, it is necessary to

add some kind of fat Body, that prevents the Destruction, and reduces Metals already destroyed: And this is the more necessary, when *Calxs* prepared either by burning, or by a Detonation with *Nitre*, are to be reduced. The *Flux* proper for this Operation is very well prepared in the Manner following: Take one Part of *common Nitre*; of *crude Tartar*, thoroughly dried, two or three Parts; pound them separately into a very fine Powder; then grind them well together; put them into an Earthen Pot, narrow at the Orifice, not glazed within, and of a Capacity three Times larger than the Powder requires: Which done, put them on a gentle Fire. So soon as the Mass begins to be inflamed with a Noise, shut the Orifice with a *Tile*. After the Detonation, this will produce a black, oily, alkaline *Salt*, easily fusible in the Fire, called *Fluxus Niger*, or *black Flux*; put it into a Pot closely shut, and in a dry warm Place, to prevent its growing moist.

Coroll. *Tartar*, being burnt alone in Vessels closely shut, or detonated with *Nitre*, is most quickly alkalized, and thus retains a considerable Part of the *Oil* which it contains abundantly, and which is fixed enough. For this Reason, it very easily turns into a reducing *Flux*. This *Flux*, therefore, on account of its alkaline *Salts*, dissolves *Earths* and *Stones*, and changes them into an imperfect kind of *Glass* (§ 97.) by a moderate melting Fire. But the *Oil*, being of a more fixed Nature, still remains concealed therein, and is requisite both to preserve Metals from being destroyed, and to reduce such as are destroyed already (§ 94.).

Scholion. I. If the Pot is glazed within, and part of the glazing comes off, and mixes and melts with the *Flux*, it is again reduced to *Lead*, and thus may disappoint the Artificer: Because, this Crust of *Glass* is applied to Pots with *Litharge* or with *Lead*.

Scholion. II. All *Fluxes* must be kept and used very dry; for moist *Salts* foam very much; and when the Operations are done in close Vessels, if the Fire is quickly increased,

increased, not being able to get rid of the Moisture, it splits the Vessels.

163. If equal Parts of the same Ingredients (§ 162.) are detonated in the same Manner, the Oil is almost entirely consumed by the abundance of *Nitre*, and the rest looks like an ash or white colour'd Salt, more alkaline and sharp than the foregoing; wherefore it is called *Fluxus albus*, or white *Flux*.

164. The *Fluxus albus* (§ 163.) is very efficacious to dissolve *Stones* and *Earths*; but of a less reductive Virtue; and destroys the Metal, when the Fire is continued a little longer than is required.

165. These *Fluxes* are likewise of very great Service, to reduce Metals from their respective *Calxs*, and to free them from the *Stones*, in which they are inherent. But when the refractory *Calx* of *Iron* is to be reduced by a great and long lasting Fire; these *Fluxes* being infinitely attenuated, though confined in close Vessels, 1. part from their oily Principle: 2. then their alkaline Salt remaining still, they begin to consume the Vessels, of what Matter soever they may be made (§ 97), and slip away, making their way through them. The first Fault is mended, by adding *Coal-dust*, because this loses not its fixed Oil, without the Help of a free Air: The other Fault is remedied with *common Glass* made of a due Mixture of *Flints* and fixed *Alkali*: For this is fusible enough, it melts with *Fluxes* added to it, and by its Viscosity in a Manner coagulates and saturates the Salt, and thus hinders it from easily corroding the Vessels.

166. Artificers compose a great many *Fluxes* with the above-mentioned *Salts* (§ 97, 130.) and with the reductive ones; nay, some use as many different *Fluxes* as there are different Ores and Metals; all which, however, we thing altogether needless to describe. It is better to have explained a few of the simpler ones, which serve for all the others, and are very easily prepared, than to tire the Reader with confused Compositions: And this chiefly, because unskilled Artificers sometimes attempt to obtain

with many Ingredients of the same Nature heaped up beyond Measure, and with much Labour, though not more properly and more securely, what might have been easily effected, with one only and the same Ingredient, thus increasing the Number, not at all the Virtue of the Things employed. Nevertheless, if any one loves Variety, he may, according to the Proportions and Cautions above prescribed, at his Will chuse among the simpler Kinds such as will best suit his Purpose, and compose a Variety of *Fluxes* with them.

C H A P. III.

Of Docimaſtical Utenſils.

167. **I** Comprehend under this Title the Vessels, Furnaces, and other passive Instruments, necessary for the conveniently and accurately perfecting of docimaſtical Operations.

I. Of VESSELS.

168. The first among docimaſtick Vessels, is the *Coppel*, or lesser Test made of *Bone-ashes*, which is a Vessel made of such Matter, that it indeed contains melted Metals, so long as they are in their true metallick State, but absorbs them, as well as all the other Bodies, when they are vitrified.

169. The Matter of *Coppels* (§ 168.) therefore, must be chosen such as can resist the strongest Fire, not running easily into *Glass* with vitrifiable Bodies, as for Instance, with *Glass* of *Lead*, and fit to be reduced into a well-coherent, though porous Mass. The best *Earth* for this purpose was found, that which is made of calcined Bones of all Animals, a very few excepted, especially Swine-bones: For when it is made of the latter it receives something metallick in it, at the same Time that it absorbs

Glass.

Glass. But the best Bones are those of Calves, Oxen, Sheep and Horses, especially the smallest, which are the more easily calcined, the longer they have been exposed to the Injuries of the Air.

170. The Calcination of these Bones (§ 169.) must be made for a few Hours, or more, according to their Bigness, in a great open Fire: Therefore, you must pick up the smaller ones, and those which are less covered with fat. You will have a sure Sign of the Calcination's being perfect, if you see not one black Spot without the Bones, nor any within when you break them.

171. When these Bones are perfectly white (§ 170), pound them in a Mortar, sift them through a very fine Sieve; or, if you have none of this Kind at hand, grind the coarser Powder upon a very hard *Stone* into a very fine Flour, and then wash it with warm fresh Water: For during the Calcination, the Bones are almost always impregnated with the *Salt* of the Ashes of the Fuel of the Fire. Then this will be an excellent *Earth* for the making of Coppels *.

172. Fish-bones, when very small, are more easily calcined than those of other Animals: Which may be easily done in a large open Earthen Vessel. These Bones being then pulverized are still better than the foregoing (§ 171).

173. Parget or Plaster made of some kinds of Spaad, is almost preferable to the aforesaid *Earths* (§ 171, 172). But it is not every Spaad will serve this Purpose. You must then, before you prepare a Quantity of this Parget, previously try whether it will succeed, or not. The Calcination of this Kind of Spaad is made in an earthen Vessel, closed with a Tile upon a gentle Fire: This occasions a little crackling, which being over, the Calcination is perfect.

174. But, as the Preparation of the Ashes of Bones is toilsome enough (§ 171, 172); and the said Kinds of Spaad not to be found every where; on this Ac-

* It is called by some *Clar*.

count, when you have a great many Coppels to make, you may supply this Want with Ashes of Vegetables. But lest the Coppels should vitrify, because of the alkaline *Salt* adhering to these Ashes, you must previously use the following Preparation. Let hot, white, and very light Embers made of soft Wood, be strained through a Sieve by pouring pure Water upon them; that all the Coals that happen to adhere to them, may be separated, and the best and finest Ashes may not fly away. Pour upon this strained Dust pure and boiling Water; stir it with a Wooden Stick; then let the Ashes subside quietly, and the Water which swims at Top, and which at first remains always troubled, be decanted: Pour new Water on the remaining Ashes, and after they have subsided a second Time, decant it again: Repeat this over and over, till the Water swimming at Top proves altogether insipid: Then pour fresh Water again, stir it with the Wooden Stick, and after eight or twelve Seconds, pour it out, as yet troubled, into a clean Vessel: Part of the Ashes will remain in the foregoing Vessel, in which the said washing has been made: Pour Water upon this Remainder, stir it and wash it likewise, and then, after a short Rest, pour it into the second Vessel: Repeat this in the same Manner, till there remains at the Bottom of the first Vessel nothing but a little *Sand*, or some other coarser Corpuscles. Let the washed Ashes rest till they subside, and the Water swimming at Top be decanted softly. Thus you will have good *Earth*, free from redundant *Salt* and *Oil*, and immutable by Fire; which, however, being reduced into small Balls, burnt again in a Potter's Oven, and then washed anew, will prove better still.

175. Finally, put a small Quantity of Ashes of the Bones of Beasts or of Fishes (§ 171, 172.) into a very clean Earthen Vessel, and a second Time calcine them during a few Hours, in the strongest Fire, wash them next with Water, then grind them upon a Porphyry into a most subtil Powder, to be kept separately,

parately, for the Uses soon to be mentioned. It is called in *German Claer*.

176. The hollow of the Coppels, which receives and contains the Metal, must be a spherical Segment, not very deep; first, that the Surface of the melted Mass, let this be ever so much diminished, be sufficiently visible to the Eye of the Artificer; secondly, that the Metal in that Cavity may melt together in one Globule. But the outsides of the Coppels must be only a small Matter convergent towards the Basis, like a truncated Cone; that it may stand firm upon its Basis.

177. But that this Figure (§ 176.) may easily be given the Coppels, you are to have *Copper* or *Brass* Moulds, the Figure of which is described (*Plat. I. Fig. I. and II.*) where we have added an exact Explanation. You likewise find their various Sizes, according to the Quantity of the Metal to be worked in the Coppels.

178. With all these Preparations (§ 168—177.) you will make the docimastical Coppels. 1. Take Ashes of Bones, of Beasts, or of Fishes alone, or two Parts of Wood Ashes (§ 174.) and one Part of dry Ashes of Bones (§ 171.) mix them well in a Mortar, or upon Porphyry; then add to them by Drops just as much Water, or of white of Eggs diluted with Water, as will be necessary to make the Matter stick together, when strongly pressed between the Fingers, and not more or less: Or if you use Spaad (§ 173.) let it be sprinkled in the same Manner with a Solution of *Vitriol*. Put a large Quantity of the wetted Dust into a small Mortar (*Plat. I. Fig. II.*) supported upon a firm Prop; press down with your Fingers the Mass poured loosely in; that the Capacity of the Mortar may be quite full of it; and lay the Remainder aside. 2. Put the Pestle perpendicular (*Plat. I. Fig. I.*) into the Mortar, and then with a Mallet drive it with three or four Blows, according to the different Diameter of the Vessel that is to be made, and make

the Mass pretty compact, taking care lest the Pestle should rub against the Sides of the Mortar. 3. Having then removed the Pestle, strew the upper Part of the Cavity of the small Vessel, with Ashes of dry Bones ground extremely fine (§ 175), which is done with the Sieve (*Plat. I. Fig. IV*): Again, put the Pestle into the Mortar, after having first wiped it with a clean Rag, and drive it pretty strongly with one or two Blows more. 4. Then have at hand a small wooden Plank, strewed a Quarter of an Inch thick with dry Ashes, put upon it the Mortar containing the Coppel already prepared, so that the lesser Basis of it be underneath; press it against the small Board: the Coppel will then easily quit its Mould: Let next the prominent Inequalities at the upper Edge and Bottom of the Coppel, be cut off with a sharp Knife: Finally, let the Coppel inverted be laid aside in a dry Place.

179. Therefore, the dry Ashes called *Clar*, must be applied to the Inside of the Coppel, that the little Inequalities most commonly remaining there, may be filled, and make a Sort of very fine Sieve, admitting through it vitrified Bodies, and retaining *Gold* and *Silver*: Thus, when the Cavity of the Coppel is carefully done over with these Ashes, it will be no great Harm, if the Mass (§ 178.) used for the making of Coppels, happens to be defiled with a small Mixture of *Sand* or of any other Powder more easy to be vitrified. And indeed it is hardly possible to avoid this Fault entirely, especially when you use Wood-Ashes. Thence the Reason is plain, why this Dust (§ 175.) must be prepared with so much Care. Therefore great Cautions are to be taken, that the Levigation of this Dust be not made upon a soft *Stone*: because Particles of it being by Chance rubbed off might spoil the Powder.

180. The Coppels ought to be rather more than less compact: the latter being always hurtful; whereas the former, by absorbing the *Glass* more slowly, does but retard the Operation a little.

181. There.

181. Therefore, Coppels made of Ashes of Bones of Beasts, of Fish-bones, and of Spaad, are excellent, as they need not be made very hot at first, and require not the Regimen of the Fire to be so strictly observed. But if you add to them Wood-ashes, it will be necessary to make the Coppels pretty hot, before you put the Metal into them: Which being neglected, the aqueous Vapours, forcing their Way out, will cause the Metal to be thrown out in Drops; for Coppels of this Kind can never be perfectly dried by the Air alone; there being always something of an Alcaline Salt adherent to Wood-ashes, which attracts the Water out of the Air: As the dark Colour of these Ashes, and the Solution of Ammoniac Salt poured upon them evidently shew. For which very reason, these Ashes are more disposed to Vitriification, than Ashes of Bones; for the latter are nearer the nature of incombustible Stones.

Coroll. Hence likewise it is plain, why the dry Powder (§ 175.) wherewith the Cavity of the Coppel is done over, separates more easily in the Operation of the Coppelling, when Wood-ashes have entered into the Matter of the Coppels: Which is vastly prejudicial; because, when these things adhere, they either increase the Weight, or cannot be got out of the Bed of Metal, without something of it being lost.

182. As to the moistening of the Matter of Coppels (§ 178.) you are to take care, (1.) Not to use a Fluid too mucilaginous and fat: For this makes Coppels so compact, that they not only reject vitrified Bodies, and yield them a very slow Passage, but also split when made very hot, losing first their oily Part. (2.) Not to use such mucilaginous Fluids, as may produce a great deal of fixt Alcaline Salt in the heating of the Coppel; as the tartareous Dregs of fermented Bodies do. (3.) Not to moisten the Ashes too much: for then the Surface of the Coppels is never perfectly neat. (4.) Some mix about one tenth Part of decanted Clay to the said (§ 178.) Ashes

Ashes; And when this is done, the Matter must be moistened with Water only; because the Clay makes the Ashes stick sufficiently together. However, take care that too much of Clay be not added; And you must always regard the several Degrees of Fatness of this *Earth*. (5) If the Ashes of Bones are not ground too coarse, their being sprinkled with pure Water, makes them so coherent, that there is no need of adding any Clay, or mucilaginous Fluid, to increase the Cohesion; for Coppels of this kind, as well as those made with Spaad (§ 173.) need hardly be made hot before the Metal is put into them.

Coroll. It is then plain, why the Operation done in a Coppel made with Ashes of the Bones of Beasts, of Fish Bones, or with Parget of Spaad, lasts a little longer, but is more securely performed, than if Wood-Ashes had been mixt to it. For as it receives more slowly a vitrified Metal, on account of its own compact Substance; so it is less to be feared, that any thing of a perfect Metal should be absorbed; though the Management of the Fire be not so scrupulously minded.

183. These small Vessels made of Ashes (§ 168.) serve for docimastick Operations not very extensive: But if a larger Quantity of Metals is to be work'd upon, we accordingly use greater Coppels, one Foot and a half broad, commonly called *Test*. But these are made with Wood-ashes; but not prepared with so much Care as (§ 174.) They add to them Brick-dust beaten very fine. In this case, they use for Moulds, either the earthen Pot, or the Iron-ring represented (*Plat. I. Fig. VIII. and XI.*)

184. The manner of making them is as follows: (1) In an earthen Vessel not glazed within, and by its Depth and Largeness proportioned to the different Quantity of Metal to be put in it. Let the inside of it be well moistened with Water; that the Ashes to be put into it may adhere the better. (2) Put the Ashes just mentioned, and moistened in the
same

same Manner (§ 178.) as was said about Coppels, into this Vessel; so that it may be half full of them: Then press them with a wooden indented Pestle, (*Plat. I. Fig. XII.*) or (if you are making but a small Test) with only a wooden Cylinder an inch thick. When pressed, add upon them some other Ashes, to be pressed in the same manner; till the earthen Vessel be almost quite full: Remove the superfluous Ashes with an Iron Rule. (5.) Let the Inequalities remaining at the Border be smoothed with a wooden-Ball rolled about: This done, cut the Cavity with a bowed Iron (*Plat. I. Fig. IX.*) that you may have a broad spherical Segment, not very deep. (4.) With a Sieve, strew this Cavity with dry Ashes of Bones of Animals, ground extremely fine (§ 175.) and to be squeezed hard by the rotation of the wooden-Ball. Thus you will have a Test, which, together with its earthen Pot, must be put in a dry warm Place.

Another Manner.

185. Let an iron-Ring (*Plat. I. Fig. VIII.*) be filled with Ashes like those already mentioned (§ 183.) in such manner, that they may rise considerably above the said Ring; then press them strongly with your Hands, or with an indented Pestle (*Plat. I. Fig. XII.*) (2.) Then, with gentle Blows of a Hammer, press the Ashes from the Circumference towards the Center in a spiral Line, and in such manner that, after having been sufficiently pressed, they may be a small matter higher than the Brink of the Ring: Or, if there are Vacancies, empty the Ring, and fill it again with more Ashes: For if you add ever so little of Ashes, the second put in do not cohere so strongly with the first, but they may separate in the Operation. (3.) This done, turn the Ring upside down, and on the other side cut the Ashes out with a Knife, to the Quantity of one third part of the Depth of the Ring, and again fill the Vacuity with the same Ashes (§ 185. N° 1, 2), in such a Manner,

a Manner, that there may remain no sensible Cavity. 4. Finally, cut out a Cavity in the larger Surface of the Ring, and in the same Manner mentioned (§ 184.)

186. The Tests, called in German *Treibscherben*, are Vessels resisting the strongest Fire, and so vastly compact, that sometimes they not only retain melted Metals, but also the very *Glass* of *Lead* itself.

187. Their Figure and Size may be the same as that of the Coppels: However they commonly are made larger. To form them, they use a wooden or brass-Mould, represented (*Plat. I. Fig. V. and VI.*) Nor is there any Difference between a Coppel and a Test, except that the Matter of the latter must be more compact and coherent.

188. The Matter fit for the making of Tests is prepared thus: (1.) Make into Balls, Clay of the best kind, and pure; and dry them in the Air, or in the Fire: When dried, pound them in a Mortar: Pour upon this Earth abundance of warm Water; let this Mixture rest a while; and when the Clay has subsided, pour out the Water which swims at top. The same Washing may be repeated, that all the minute Lumps of the Clay may be well soaked with Water, and any thing of *Salt* contained in them be washed off. (2.) Then add of the purest Sand, of Powder of calcined Flints ground, and well washed, of faulty but clean *Hessian* Crucibles, or of any incombustible *Stones* ground very fine, such Quantity as will render the Mass thick, hardly adhering to the Hand of him that kneads it, and hardly pliant when reduced into a small Lamina. This Mass will be fit for the making of Tests.

189. But, before you make a great Quantity of Tests with this *Earth* (§ 188.) it will be proper first to put into a single one made with it, a Quantity of *Glass of Lead*, and to expose it for an Hour or more to the strongest Fire. Thus you will be sure,

* Tobacco-pipe Clay, p. ii. Brick-dust, p. i. Sturbridge Clay alone, or Sturbridge Clay, p. ii. Windsor Loam, p. i. will make very good Tests to roast Ores in.

whether

whether it can resist Fire, and the *Glass of Lead*: For you cannot determine the exact Proportion of the Ingredients on Account of the Variety of Clays. Nature now and then affords in some Places Clay so well tempered, that it is extremely proper for the making of Tests, without any Preparation, or without a Mixture of another Matter: Sometimes it only wants to be washed: But most commonly it must be first prepared in the abovementioned (§ 188.) Manner.

190. If then the Mass under Trial (§ 189.) turns into Glass: you must add to it some of the aforesaid Dusts of Stones, especially of incombustible Stones. However, take care not to add too much of pulverized Chalk; for if the Matter is tempered with that alone, the Tests made with it, will indeed resist Fire the more; but, being too porous by this means, they yield a Passage to Litharge; which being absorbed, they soften to such a Degree, that they fall asunder of themselves, or are totally crushed when you take hold of them with Tongs.

191. Tests are made in Moulds (*Plat. I. Fig. V. and VI.*) after the following Manner. Rub a little Mortar and the Pestle lightly with Bacon or Oil; then fill first the two thirds of it with prepared Clay (§ 188.) and then with your Thumb make a small Pit in the middle of the Clay; put the Pestle upon it, and press the Matter with Blows of a Hammer, the stronger the better; and finally take the Test out of the Ring, in the Manner mentioned (§ 178. N. 4.) as was said of Coppels.

192. The clay Matter here to be used, must be so stiff and dry, that it may break the Moment you bend it with your Hands: For if it is too soft, it will hardly be possible to have any intire Tests, or at least they are mishapen. Nor yet must the Clay be over dry; otherwise it would be difficult to fashion.

193 Tests thus made (§ 191.) and dried in a dry and moderately warm Place, may serve immediately, without being previously made hot; unless *Salts* or *Litharge* are to be managed therein: For these Things

Things, being melted in Vessels not baked before, soon perspire through them.

194. The assaying Oven (*Fornix docimasticus*) or as others call it *Tegula*, *Testudo*; in German, and English *Muffle*, is an arched Covering, resisting the strongest Fire, which in the Operation preserves the Coppels and Tests (§ 178, 191.) from the falling of Ashes and Coals into them, and at the same time of such a Form, as is no hindrance to the Action of the Air and Fire, nor to the Inspection of the Assayer.

Coroll. You may then make your Muffles of what Form you please, provided they have the said (§ 194.) Conditions requisite.

195. But those which serve for Essays made in Coppels, are most commonly made semi-cylindrical; but like a hollow Hemisphere, when greater Ash-Vessels (§ 184, 185.) are employed.

196. the Muffle must have Holes in it; (1.) That the Assayer may easily look into it: For which Purpose the forepart of it must be quite open (*Plat. II. Fig. I.*) (2.) That the Air may the better act in Conjunction with the Fire, and be incessantly renewed: For there is hardly any Fumes produced without the Action of it; which however is of an absolute Necessity in the Vitrification of *Lead*: For when the Air is once filled with a certain Quantity of Vapours, it hardly admits any more after that; for which Reason a constant Renewal of Air is necessary. (3.) Besides, these Holes serve for the Regimen of the Fire: For the cold Air rushing through the large Hole before, cools the Bodies put in the Muffle; or if, after having put some Coals in it, you shut this Aperture in part, or even intirely with a Door added to it, the Fire increases to the highest Degree; which can hardly be done so quickly by the breathing Holes of the Furnace. (4.) That the arsenical Vapours of *Lead* and *Antimony*, which pass through the Holes made in the Basis of the Muffle, may not be offensive to the Assayer standing by it.

Coroll.

Coroll. Therefore, when you are to fix the Height, Length, and Depth of Muffles, you must consider, how many Vessels, and of what Size, are to be introduced at once into it, and that the whole Inside of the Vessels, both foremost and hindmost, may be within the Reach of the Assayer's Eye: To which last Point you must have a special regard. But most commonly they are of the requisite Dimension, when four Inches high, six or eight Inches long, and four or six Inches broad. The Segments cut off at the Basis for the lesser Holes, must be so high as that at least the small Vessels put under them, may not be tainted by Coals and Ashes falling into them. For these hinder the Vitrification of *Lead*, and the Destruction of the other Metals and the Semi-metals, and reduce them entirely when already destroyed: But the *Scoriae* spoiled by Ashes, soften and retard the Operation.

197. You must have wooden Moulds, for the forming of these Muffles, (*Plat. I. Fig. 13*).

198. The Matter which they are made of, is the same as that of Tests (§ 188); provided it be a little more moistened and pliant *.

199. To form your Muffles, gather in one Mass a sufficient Quantity of *Clay* prepared (§ 198.) and moistened, so as to be somewhat pliant; kneed it well with your Hands, put it upon a Plane of *Stone*, or any other that may be not much changed by the Moisture; extend the Mass evenly into a Cake a little longer than the Muffle to be made, so broad as to exceed a small Matter the Border of the said Muffle, and so thick as that two or more thin *Laminas*, about two geometrical Lines thick, may be cut off from it: Which is easily done, by rolling upon the Mass of *Clay* a wooden Rolling-pin, strewed first lightly with Ashes or Chalk. 2. With a thin brass

* Note Windsor Loam alone, or Sturbridge Clay alone, will make very good Muffles: but the best are made of Sturbridge Clay, p. ii. and old Muffles, or melting Pots, made of Sturbridge Clay, which have been used in the fire, beat to fine powder, p. i. and mixt.

Wire well stretched out, cut off from the Cake (N^o 1.) a thin Plate, with great Caution, lest it should break; take it away, and having first smeered it over with Bacon or Oil, clap it upon the convex Part of the Mould (*Plat. I. Fig. XIII.*) 3. Then in the same Manner shut the hinder-Part of the said Mould, with a like *Lamina* made Semi-circular, so that the Border of this *Lamina* may be joined together with the hinder-Border of the *Lamina* upon the convex Part of (N^o 2.) the Mould; which is effected with Water, without which the hinder-*Lamina* would not stick to the fore one. 4. By the same Method, you may, if you think it proper, annex the Bottom, to the inferior Edges of the above-mentioned two *Lamina*'s. Otherwise, you may leave the Bottom moveable, making it of a small *Lamina* cut off from the Cake: In which Case, however, it must by its Breadth exceed by half an Inch the Sides and hinder-Part of the Muffle (N^o 2. and 3), that the latter may with the greater Security stand upon it as a Basis. Then, with your Hand wet, rub the Muffle thus made all over; that the small Chinks, perhaps not seen, may by this Means be closed up on every side, and the *Clay* closely joined to the Mould. 6. When the Muffle applied to the Mould has been for some Hours in the dry Air, and it is become hard, cut off from it some Pieces, in the Manner aforesaid (§ 196. *Coroll.*) and (*Plat. II. Fig. I. and II.*) which done, take the Mould softly away: For if the Muffle should dry perfectly upon it, it would certainly crack. When afterwards the Muffle exposed to the Air for some Days, is quite dried, it is at last baked in a Potter's Oven, or even in the assay-Oven hereafter to be described; in such Manner, nevertheless, that in the latter Case, the Coals, being lighted above first, may communicate the Fire slowly down to those underneath: Otherwise, indeed, the excessive Force of the Fire would certainly occasion Cracks in the Muffle. For which Reason, it is much securer, to bake it in the first Manner mentioned.

200. If you adapt to the Convex Mould (*Plat. I. Fig. XIII.*) another Concave one (*Plat. I. Fig. XIV.*) in the Manner described in the Explication of the Figure just cited, so that the *Clay* between them may be formed by a strong Pressure; this will make Muffles much more solid with less Trouble, less apt to crack, and more capable to resist the Fire. Now this is done in the following Manner. Put *Clay* a little drier than the foregoing, or that kind of *Clay* which is improperly called *French Clay**, into the hollow Mould, rubbed first with Bacon†, and with your Hands extend it on the Semi-cylindrical Cavity of the Mould, and against the Board at the hinder Part (*Plat. I. Fig. XIV. l m*) then put upon the extended *Clay* the Convex Mould, rendered smooth with Bacon; so that the Sides of it may be equally distant from the upper Border of the concave Mould: Then put upon it the upper Board (*Plat. I. Fig. XIV. n. o.*) with Screws belonging to it (*g*), and by means of them press it so, as that the Board put upon it may touch the Body of the concave Mould: Which done, press finally the Convex Mould as much as possible against the other, by means of the hinder Screws, (*Plat. I. Fig. XIV. i. k*); then loose the Screws, and, after having taken away the hinder and upper Boards, take out the Convex Mould: Which is done by means of a Screw (*Plat. I. Fig. XIV. lit. p*) that serves as a Handle. Thus you will have a Muffle formed, which is easily taken out of the cylindrical Cavity, and from the Basis of which Segments may immediately be cut off: Finally, dry it well, and bake it as the foregoing ones (§ 199).

201. When larger Ash-Vessels or *Tests* (§ 183.) are to be covered, they use large spheroidal Muffles (*Plat. II. Fig. III.*) made of cast *Iron*, or they make Muffles of the same Kind with *Clay*, and upon Moulds of the same Figure (*Plat. II. Fig. IV.*). Then the Mass of *Clay* is extended with wet Hands only from the Top

* *Windsor Loam* is as good as any.

† *Black-Lead* powder'd is better.

of the spheroidal Mould towards the Borders; and thus a Muffle is made with no great Trouble.

202. You see the Figure of the *melting Pots* and *Crucibles* (*Plat. II. Fig. V. and VI.*). These Vessels, when small, are made with a Basis a little wider; both that they may not be thrown down, upon what they are set on, by the Coals put upon them, and lest they should fall, when taken out of the Fire, and put upon a Pavement not exactly horizontal.

203. These Vessels (§ 202.) are formed in wooden or brass Moulds divided into two Parts, from Top to Bottom, that they may be disjoined and put together again. For this Reason, they adapt a broad iron-Ring, to the outside of the Mould, in such a Manner, that the two Parts of the Mould may be joined close together, by applying the Ring to them, and separated, by taking it away: Which appears better from (*Plat. II. Fig. VII. and IX.*) than from the Description. However, this concave Model procures you only the external Form of the Vessel, but the inward Cavity is made with a Pestle (*Plat. II. Fig. VIII.*).

204. The Matter these Vessels (§ 202.) are made of, may be the same as that of the Tests and Muffles (§ 188 to 190). Observe only, that it is proper to make use of the like Vessels, which have already sustained a great Fire, and are very clean, reduced into Powder, to correct the Stiffness of the *Clay*.

205. To make Vessels (§ 202), with this *Apparatus* (§ 203), put your hollow Mould within the Iron Ring (*Fig. VII. and IX.*), and lay it upon a firm Support: Then fill the Cavity of the Mould, with a sufficient Quantity of Matter (§ 204.) very stiff; which Quantity can hardly be determined, otherwise than by Experience: Then press it down with your Fingers, or with a wooden-Stick, leaving an hollow in the Middle; so that the Matter may rise a little beyond the Sides of the hollow Mould: Finally, put into it the Pestle (*Fig. VIII.*) rubbed over with Bacon, and drive it down with several strong Strokes
of

of a Mallet : Then take away the Pestle gently ; and if the Matter is hard enough, and the hollow Mould sufficiently polished, the Vessels may be immediately taken out of the hollow Mould, by removing the Ring: But if the Matter is too stiff, or too moist, and the hollow Mould not sufficiently smooth, take away the Pestle and put the Mould in a dry warm Place; and by this Means, the Mould may be opened, and the small Vessel be taken out in a few Minutes. When these Vessels (§ 204.) are sufficiently dried, they must be baked in a Potter's Oven.

206. The larger Crucibles and melting Pots are made in the same Manner. Only instead of a Mallet we use a Press, to force the Pestle into the concave Mould.

207. There are Cautions to be used in the making of these Vessels. (1.) A sufficient Quantity of Matter must be put all at once into the Mould: For if you add to the Matter once compressed a new Lump of the same, it does not cohere with the first: Which happens likewise, when a Quantity of small solid, or at least compact Masses are put into it, without having first been well united by handling. Hence come many Chinks, and Pores, in the drying and baking, which often cannot be discovered by the Eye, nor by the Sound when the Vessels are struck, and mean while yield a quick Passage through them to the Salts. (2.) If these Vessels are not made with a large Bottom, the concave Mould must not be besmeared with Bacon: Otherwise, when you take out the Pestle, the Vessel sticking to it, commonly comes out of the concave Mould along with it; nor can it afterwards be taken off from the Pestle, unless you break it.

208. In Fusions, it is often necessary to cover the Vessels with Tiles: Wherefore I give a Picture of them (*Plat. II. Fig. X*). These are made of the same Matter as the melting Pots and Crucibles*:

* A Piece of common plain Tile may serve as well, if made to fit the Vessel.

For your common Earthen-ware, which is generally glazed with Litharge, grows clammy in the strongest Fire, and sticks to the Vessels; so that they are taken off with difficulty, or even melt entirely. It is then better to cut off Pieces like Tiles, with a Knife, from a Cake of Clay (§ 188.) extended upon a flat Table, of the Bigness requisite, according to the different Diameters of the Vessels to be closed. Then pare away the Borders of the inferior Surface of the Plate so cut off, which is to touch immediately the Vessel to be closed, leaving a Shoulder all round, by means of which the Tile is fastened in such a Manner, that it is not easily removed by the Poker, or when fresh Coals are put on the Fire. Finally, you put in the Middle of the outside a small Bit of the same Clay; that it may be easily taken away or put on the Vessel again with Tongs, by means of this Kind of Handle.

209. The small separatory Cucurbites or Matrasses (*Plat. II. Fig. XI.*) must be made of very transparent Glass, and yet capable of resisting the most corrosive *Menstrua*, lest they should be corroded. Nor must they be too thick, especially at the Bottom; for, when they are very thick, they easily burst in the Fire. Let them be eight or ten Inches high, with a very narrow Orifice, hardly half an Inch wide; lest the Matter therein contained, being in a violent Ebullition, should rise over the Mouth of the Vessel, or at least Part of it be thrown out in small Drops, like a thin Rain, to which there is always a little of the Metal adhering; that in short a greater Repercussion of the Fumes may be made. The bottom has a sufficient Capacity, when it contains one or two Ounces of *Aqua Fortis*. It is besides proper, that their Orifice be turned backwards into a broad Margin or Lip, lest the Solutions, when poured out, should run down along the Sides of the Vessel *.

210. To support such a small Cucurbite, (§ 209.) we use a Trivet (*Plat. II. Fig. XII.*) so made, that

* A clean Florence Wine Flask will serve upon occasion.

small Cucurbites of this Kind, and some of a Size a little larger, may be put upon it with equal Security. Therefore, let the Feet of it be spread wide asunder, that some lighted Coals may easily be put under or taken away, and all the Appearances of the Solution be carefully examined.

211. Next to this, we use a Copper Skellet or Glass Bowl (*Plat. II. Fig. XIII.*) furnished with an Handle and a Nib, for the washing clean of the *Calx* of *Silver* precipitated by *Copper* out of *Aqua Fortis*. It is the better when made of *Copper*, because it then can expel whatever Quantity of *Silver* remains in the Solution after the Precipitation. For there remains almost always something of it. The Diameter of this Vessel must be six Inches or more, its Depth about four Inches.

212. You must furthermore have at hand a small golden Dish, one Inch broad, and half an Inch deep, (*Plat. II. Fig. XIV.*) which serves to heat the Gold in red hot, from which another Metal has been eroded in a docimastical Operation; that any remains of the *Menstruum* still adhering to it may be dissipated. It must be made of the purest *Gold*: For in an Earthen Dish, grown porous and brittle by the Separation, part of the *Gold* might be scraped off: And, if it were made of another Metal, it would either melt, not being able to resist so great a Fire, or cast scaly *Scorias*, or even be corroded by the *Menstruum* remaining in the *Gold*; and thus would both ways diminish the weight of the *Gold*, and deceive the Assayer.

213. You must likewise have a particular Iron Trivet (*Plat. II. Fig. XV.*) adapted to this Dish (§ 212), to support it.

214. The washing Trough or Tray (*Situla lavatoria*, *Plat. II. Fig. XVI.*) is an oblong Vessel, in which the lighter and unprofitable Parts of the Ores are washed off, by pouring Water upon them and stirring it. It must be made of *Earth* or of *Stone*, not glazed, though of a clean smooth Surface. How-

ever, any other Vessel of a middling Capacity, and pretty wide, may serve for the same Use.

215. Finally, you must have, for the Granulation of *Lead* and *Tin* above described (§ 44.) a granulating wooden Box, with its Cover, and so large as that some Pounds of Metal may be contained and well shaken in it. You have the Figure of it (*Plat. II. Fig. XVII*).

216. But to granulate Metals the wet Way, you may use any Vessel, if it be but wide, filled with cold Water, which must be stirred about with a Broom. For Instance, the Metal, when a good Quantity of it is to be reduced into Grains at once, is first melted; then with a very small red hot Crucible, held with a Pair of Tongs, it is laded up out of the larger Vessel wherein is the whole melted Mass, and while another Man stirs the Water about with the Broom, which he then raises one half above the Water, you pour it all at once upon the said Broom, that it may fall through it into the Water. But the Sprigs of the Broom must not be too close, lest the Metal, being stopped by so many Obstacles, should wax cold too soon; and, by being detained between their Interstices, adhere to them, and not reach the Water. When all the Metal has been thus injected, and the Water decanted, you will find it divided into small Particles.

217. Some use a particular Machine, made on purpose for this Work, and represented (*Plat II. Fig. XVIII*). They take a wooden Cylinder, six Inches long, and ten in Diameter, and adapt to it an Axis and Handle, like a Grindstone. Then cut all round longitudinally six or eight Channels about three Inches deep. Then put the Cylinder thus prepared upon a Tub or wide Vessel, like that described (§ 216); so that the Axis of it, being received by Semi-circular Cavities cut in the Border of the Vessel, may be kept steadily, lest it should fly out of its Place in the Rotation. Then the Vessel is filled with Water to such an Height, as that one third Part of the Cylinder may be immersed in the Water; then throw the

melted

melted Metal, laded up after the Manner mentioned (§ 216.) upon the Cylinder just described, which must be turned all the while upon its Axis with the Handle. By this Means, your Metal, made thinner than after the foregoing Manner (§ 216.) will be comminuted into thin Plates rolled together.

Scholion. *By both these Methods (§ 216 and 217.) combined, you may very well and with Security granulate Gold, Silver, and the several metallick Mixtures: But there is always some Risk in the granulating of Copper: To avoid which, you must pour it only in a small Quantity, and with a small Stream: Which is more securely done, if the Transfusion is made through a red hot Crucible, having a few small Holes at bottom; that the Copper, being as it were previously divided by this straining, may thus fall upon the Broom (§ 216.) or upon the Cylinder (§ 217).*

218. The Cement-Pots are cylindricall Vessels, made of Potter's Clay, with Tiles adapted to them, and turned by Potters. The Size of these Vessels must be proportioned to the Quautity of Cement to be put (§ 153.) into them. However, it is not proper to make them above eight or ten Inches broad: For, when larger, the Fire acts with Difficulty and Inequality, especially in the Middle of them.

219. You are to observe, that, in the making of these Earthen Vessels (§ 218.) and of their Covers, all kinds of Clay contract and take up a lesser Space in the drying and baking: Insomuch however, that the purer Clay contracts one tenth Part of its Diameter: But the more it is mixt with Sand, or some other Dust of Stones and Vessels already baked, the less it diminishes; this Diminution being sometimes hardly perceptible. Therefore, if a Vessel, or a Cover of a determined Size, is to be made of Clay; it must be made greater than the required Bulk, in proportion to the Diminution, which Experience teaches you, Clay, either crude or prepared, undergoes in the drying up of it.

220. The melting-Cone (*Plat. II. Fig. XIX.*) serves for the Precipitation of melted Metals, which is made when two Bodies, melted together, and yet not mixing perfectly with one another in the Fusion, separate of their own Accord into two Strata, on account of their different specifick Gravity. This Precipitation might indeed be made in the same Vessel wherein the Fusion is made: But, in this Case, you would be always under the Necessity of breaking the melting Pot every Time; because the Part precipitated cannot be got out of it, when this Vessel is intire. Therefore we use for this Work the above-mentioned kind of Cone, into which the melted Mass is poured, and out of which it may be easily taken, when the Precipitation is perfect. But as the Quantity of the Matter to be precipitated is often but small, the conical Figure has, on this account, been assigned to the melting-Cones, doubtless, that the heavy Matter, subsiding to the Point of it, may be collected into one solid *Regulus*.

221. The melting-Cone is made of Copper or of Brass, that the Inside of it may be sufficiently polished. When it is made of Brass, you must take care that it be not made too hot: For then, when you strike it with any force, it easily splits, on account of the Brittleness of this Metal in a great Fire.

222. When the Quantity of the melted Matter to be precipitated is considerable; you may use, instead of a melting Cone (§ 221), a large Brass or Iron-Mortar, or any large Iron-Vessel whatever.

223. Finally, when melted Metals or Semi-Metals are poured out, in order to be examined closely, or afterwards assayed in part; it is proper, in the pouring out, to give them an oblong Form not over-big: Because they, by this Means, are more easily divided, and cut into small Bits. In order to this, they use a Set of Moulds (*Plat. II. Fig. XX.*) called an Ingot, having one or many prismatical or semi-cylindrical Furrows, of different Sizes, and well polished, with a very

a very long Handle, and made of Iron, the properest Matter for this Instrument.

224. But when a small Mass of precipitated Metal is forthwith and entirely to be put into a Coppel; they chuse to use a Mould, having the Form of a Segment of a little Sphere, and made likewise of Iron; such as is commonly employed in pouring out such Ores as have been extracted and scorificated by Lead. By this Means you are sure to hinder the small metallick Mass, from scraping, with its angulous Surface, any Particle of the tender Bottom of the Coppel, while it is put into it, and, by this Means, from making it rough.

225. All these Moulds (§ 221, and 224.) must be well heated, before the Metal is poured into them; lest they should happen to be a little wet, or contract a Moisture, especially in cold Weather, by the sudden Heat of the melted Mass being poured into them: In which Case, the Matter poured in is oftentimes dislodged with very great Danger.

226. Moreover, they must be previously smeered over with Tallow, that the *Regulus's* may be more easily taken out of them, and that the Cavity of the Moulds may not be corroded, by the Mass poured into them. But if a very great Quantity of Metal is to be poured out, especially of a very sulphureous Metal, or precipitated by means of Sulphur; the smearing of the Cone or of the Mortar with Tallow is hardly sufficient, to prevent the Corrosion just mentioned: Because the large Mass of the Matter poured in remains hot for a considerable while. Therefore, in this Case they use a Lute, reduced to a thin Pap, with Water, which, being applied very thin to the Inside of the Cone, or of the Mortar, is afterwards dried up. Thus, by means of this Crust, the Action of the Sulphur upon the Metal of the Cone is certainly prevented. Nay, pure *Copper* itself, though it be melted with no Sulphur, operates something like this: Wherefore, it is necessary in this Case to use the said Precaution.

227. Finally,

227. Finally, Affaying requires that you should have two Mortars; one of *Iron* and deep, to beat Bodies small; the other less deep, of *Iron* or *Wood*, and wide; this must have a wooden Pestle. The latter, most commonly of *Iron*, serves for Amalgamations: For Iron-Mortars are most fit for this Work; because, though something of the Iron be eroded by the Trituration, it nevertheless mixes not with the Amalgama: So that *Iron* is to be preferred to all other Metals, in Operations of this kind. Besides, *Mercury* may be moderately heated therein, whereby the Amalgamation is very much accelerated: Which cannot be so easily effected in a Wooden-Mortar.

228. Besides, for some Operations not directly belonging to the Art of Affaying, though it is proper that the Assayer should be able to make them, by help of his own Skill, you must have distillatory Vessels, such as Earthen and Glass-Cucurbites and Retorts: But these being sufficiently known, and described every where in chemical Books, I need not here be very particular in describing them. I shall only observe, that the Glass-Vessels, which are to sustain a great Fire, are the better as they are thinner: For, when thick, they soon split. But it is the contrary for the Recipient, which must be thicker.

229. When the Vessels (§ 228.) are exposed naked to the greatest Fire; it easily happens, that they burst, by throwing fresh cold Fuel into the Fire: For the preventing of which, you must have Recourse to Lorication or Coating. This is performed in the following Manner: Take some of the same Matter, of which the Muffles and Crucibles are made (188), and, instead of Water, moisten it with fresh Blood, not yet coagulated, and diluted with twice or thrice the same Quantity of Water, to make a thin Paste of it: Then add to this Paste Cow-hairs, or others not very long nor stiff: And, if you have at Hand Glass pulverized, and sifted, it may also be of Service, to mix some of it with the rest. Then with this Mass besmear

besmear your Vessel with a Pencil, and dry it: When dried, besmear it a second Time, and dry it again: Repeat this a third and fourth Time, till the Vessel be covered over with a Crust or Coat, one third or fourth Part of an Inch thick.

Scholion. *To hinder the Blood from coagulating; you must, when it is just let out of the Animal, stir it with your Hand or with a Stick, till it is quite cold: Being thus attenuated, it will remain for some Days without coagulating.*

230. When you are to distil strong corrosive Spirits, it is proper, for the shutting of the Vessels (§ 228.) close, to mix with the abovesaid Paste, (§ 229.) Bole, worked with Whites of Eggs diluted with Water, in a Quantity not to be determined otherwise than by Experience: This will give you a Lute, which will confine strong Vapours.

II. Of FURNACES.

231. As the Practice of Assaying consists chiefly in the refining of Fossils by Fire; you are to have Instruments, in which the Fire may be contained, applied to the Subject, and augmented or diminished to any Degree at your Pleasure.

232. The first Furnace, peculiarly called the Assay-Oven (*Plat. III. Fig. I.*) is made in the following Manner. 1. Make with Iron Plates, a hollow quadrangular Prism, eleven Inches broad, and nine Inches high, (a a, b b), ending at Top in a hollow quadrangular Pyramid (b b, c c) seven Inches high, terminating in an Aperture at Top seven Inches square. But this Prism must be closed at Bottom with such another Iron Plate, which serves as a Basis or Bottom to it (a a). 2. Near the Bottom make a Door (e) three Inches high, and five Inches broad, that leads to the Ash-hole. 3. Above this Door, and at the Height of six Inches from the Basis, make another Door (f), of the Figure of a Segment of a Circle, four Inches broad at its Basis, and three Inches

ches and a half high in the Middle. 4. Then fasten three Iron Plates on the fore-Part of this Furnace: Let the first of them (g g) eleven Inches long, and half an Inch high, be clapped, its lower Edge, against the Bottom of the Furnace, with three or four Rivets, in such a Manner, that there may be between the upper Edge of the said Plate and the Side of the Furnace, a Groove so wide, as that the Sliders of the lower Door (k k) may be put into it, and freely move backwards and forwards therein: These must be made of a thicker iron-Plate. The second iron-Plate (h h), eleven Inches long, three Inches high, and perfectly parallel to the foregoing Plate, must be clapt in the Space between the two Doors, in such Manner, that both the upper and the lower Edge of it may form a hollow Groove with the Side of the Furnace. One of these Grooves, which looks downwards, serves to receive the upper Edges of the Sliders, that shut the lower Door (N^o 2). The other, that looks upwards, is to receive the inferior Edges of the Sliders of the small Door above (N^o 3). The third Plate (i i) which is like the first, must be rivetted close above the upper Door, in such Manner, that it may form a Groove looking downwards, and contiguous to the upper Edge of the upper Door (N^o 3.) 5. In order to shut both Doors (N^o 2. and 3) you must adapt to each of them two Sliders made of Iron Plates, that may move within the above-mentioned Grooves (k k l l.) But the two Sliders belonging to the upper Door (N^o 3.) must have each a Hole near the Top; that is, one a small Hole $\frac{1}{5}$ Part of an Inch broad, and one Inch and a half long (m); and the other a Semi-circular Aperture, one Inch high and two Inches broad (n). Let besides each Slider have a Handle, that they may be laid hold of, when they are to be moved. 6. Moreover, let five round Holes, one Inch broad, be bored in the Furnace: Two of which must be made in the fore-Part of the Furnace (o o), two others in the back Part, all at the Height or five Inches from the Bottom, but three Inches

Inches and a half distant from each Side of the Furnace; and finally, a fifth Hole (p), at the Height of one Inch above the upper Edge of the upper Door (f). 7. In short, let the Inside of the Furnace be armed with iron-Hooks, jetting out half an Inch, and about three Inches distant from each other, to fasten the Lute with which the Furnace is to be covered over within. 8. Let then an iron, moveable, hollow, quadrangular Pyramid (q) three Inches high, be adapted to the upper Aperture (d) of the Furnace at the Basis seven Inches broad, ending upwards in a hollow Tube (r) three Inches in Diameter, two Inches high, almost cylindrical, though somewhat convergent at Top. This prominent Tube serves to support a Funnel or Flue, which is almost cylindrical, hollow, made of Iron Plates, and two Foot high (t), and which, when a very strong Fire is required, is put perpendicularly upon the shorter Tube, in such Manner, that it enters close into it one Inch and a half or two Inches deep, and may again be taken off at Pleasure, when there is no need of so strong a Fire. But this pyramidal Cover (q) must besides have two Handles (s s) adapted to it, that it may be laid hold of, and thus be taken away or put on again. And that this, being put on the Aperture (d) of the Furnace, may not be easily thrown down, let an Iron Plate be rivetted to the right and left upper Edge of the Furnace (c c), and be turned down towards the Inside, so as to make a Furrow open before and behind, into which the lateral Edges of the Cover may enter and be fastened, and at Pleasure be moved backwards and forwards, whenever it must be put on, or removed. 9. Let a square Ledge, made of a thick iron-Plate (*Fig. II.*) be fastened at top of the upper Edge of the lower Door (e); this is designed to support the Grate and the Lute. But it must be made of two Pieces, that it may be easily introduced into the Cavity of the Furnace. Thus you will have an Assay-Oven, which must afterwards be covered over inwardly on the Inside with Lute: This you are to do as follows:

233. That the Fire may be the better confined, and the *Iron* not to be destroyed by growing red hot, the whole Inside of the Furnace (§ 232.) must be covered over (See *Plat. III. Fig. III. and IV.*) with Lute, one Finger, or one Finger and a half thick. The Lute fit for this, is made with a Mass of *Clay* (§ 188, 190), or with *French Clay*, moistened with three or four Times as much of Ox-Blood diluted with Water *. But before you cover the Insides of your Furnace with this Lute, you must first put within the Furnace small iron-Bars, equal in Length to the Diameter of the Oven, quadrangular, prismatical, half an Inch thick, having their Extremities supported by the Ledge (§ 232. N^o 2), and $\frac{3}{4}$ of an Inch distant from each other; and you must fasten them so, that their flat Sides may be oblique with regard to the transverse Section of the Furnace, and that the two opposite Angles may look one upwards and the other downwards; the Bars must not be laid flat but edge-ways, by which Situation, you hinder the Ashes of the Fuel of the Fire from being detained too long, between the Interstices of the said iron-Bars, and from making an Obstruction, that would oppose the free Draught of the Air (See *Plat. III. Fig. IV.*). The Furnace being then covered over with Lute, and dried up by a gentle Heat, is at last fit for domestic Operations, and especially for such as must be performed in the Assay-oven (§ 194.)

* The best Lute, and easiest to be had at *London*, is a Sort of *Clay* called *Windsor-Loam*, which must be mixt pretty stiff, and pressed into the Inside of the Furnace, first wetted with Water, and, when the *Clay* begins to dry, it must be beat down close to the Sides, with a wooden Mallet; then the Unevennesses and Cracks filled up with fresh *Clay* somewhat moister, so as to be made smooth and even with a Trowel, and then left to dry gently, and if any Cracks happen they must again be filled up. If any Pieces of this Lute are broken off by the Fire; let it be quite cold and wet, the Edges of the old Lute and fresh *Clay* will unite to it, and fill up the Holes; if the Crack is but small, you may use the Furnace again immediately, even before the fresh *Clay* is dry.

234. If then an Operation is to be made in the Furnace hitherto described (§ 232, 233), you must let through the four lower Holes above described; of the Furnace (See *Plat. III. Fig. I. o o*) placed before and behind, and directly opposite to each other, two iron-Bars one Inch thick, and long enough that their Extremities on every Side may jut out of the Holes, a small Matter. These serve to support the Muffle, and its Bottom (See *Plat. III. Fig. III. and IV*). You then introduce the Muffle through the upper Aperture of the Furnace (*Fig. I. d.*) and place them upon the above-described iron-Bars, in such Manner that the open fore-side of it be contiguous to the inward Border of the upper Door f. (See *Fig. III. and IV*). The Fuel of the Fire is introduced through the Top of the Furnace (d); the Cover of which, on this Account, must be moveable, and not very heavy (q). The best Fuel for the Fire is Charcoal made of the hardest Wood, especially of Beech, broken into small Pieces of the Bigness of an Inch, wherewith the Muffle must be covered over some Inches high *. We then reject larger bits of Coals, because they cannot fall through the narrow Interstices, between the Sides of the Muffle and those of the Furnace, and cannot of course sufficiently surround the Circumference of the Muffle: Whence it happens, that there are on every Side Places void of Fuel, and the Fire is either not strong enough, or unequal. But, if on the contrary, you use Coals too small; then a great Part fall immediately through the Interstices of the Grate into the Ash-hole; and the tenderest Particles of them turn too soon into *Ashes*, and, by increasing the Heap of *Ashes*, obstruct the free Draught of the Air, which is here greatly requisite.

* *Scotch Coal* or *Kennel-Coal* (but not *New-Castle* or *Sea-Coal*) broken into small Pieces, may be mixed with an equal Quantity of *Charcoal*; or, if any Ores require long roasting, the Fire may be first kindled with *Scotch Coal*; but the Operation is best finished with only *Charcoal*.

235. A perfect Management of the Fire is most commonly necessary, in the performing of Operations in this Furnace (§ 232, 233): Therefore, the Reader must give Attention to what follows. If the Door of the Ash-hole (*Plat. III. Fig. I. e*) is quite open; and the Sliders of the upper Door (*f*) drawn towards each other, so as to touch one another in the Middle of the Door; and if, besides, the Cover (*q*) and the Funnel (*t*) adapted to its Tube (*r*) is upon the Top (*d*) of the Furnace, the Fire will then be in the highest Degree possible: Though in the mean Time it is hardly ever necessary to put the Funnel on, except in a very cold Season. But if, after having disposed the Furnace in the Manner just described, you put red burning Coals into the open upper Door (*f*) of it, the Fire is still more increased thereby: However, this Artifice is never, or very seldom, necessary. When you shut the upper Door, with only that Slider, that has a narrow oblong Hole in it (*Plat. III. Fig. I. m*) then the Heat becomes a little less: But it diminishes still more, when you shut the Door with the other Slider, that has in it the Semi-circular Hole (*n*), which is larger than that of the first Slider: Nay, the Heat again is less, when you take away the Funnel put at Top of the Cover: Finally, the Door of the Ash-hole being either in part or totally shut, the Heat is still diminished, because the Draught of Air, so necessary to excite the Fire, is thereby hindered. But if, besides all these, you likewise open the upper Door quite; then the cold Air, rushing into the Muffle, cools the Bodies put under it, that are to be changed, to a Degree never required in any Operation, and such as will entirely hinder the boiling of *Lead*. If, during the Operation, the Fire begins to decay, or to grow unequal, it is a Sign that there are Places void of Coals, between the Sides of the Furnace and those of the Muffle: Therefore, in this Case, you must stir your Coals on every Side, with an Iron Rod, which is to be introduced through the upper Hole (*p*) of the

the Furnace; that they may fall together, and thus act in a proper Manner, and equally.

236. However, you are to observe, concerning the Regimen of the Fire just described (§ 235) that though the *Apparatus* is made with all the Exactness mentioned, nevertheless the Effect does not always answer it: The Cause of which Difference has most commonly its Origin in the various Dispositions of the Air. For as every Fire is more excited by Coals in proportion, as the Air more condensed, and more quickly agitated, strikes them more violently (which the Effect of Bellows plainly shews) it thence appears, that in warm and wet Weathers, when the Atmosphere is light, the Fire must be less efficacious in Furnaces; that likewise, when several Furnaces situated near each other, are burning at the same Time, the Fire is in part suffocated; because the ambient Air is thereby rendered more rare and lighter. The same Effect is produced by the Sun, especially in Summer-time, when it shines upon the Place where the Furnace is situated. The Atmosphere, on the contrary, being heavier in cold dry Weather, excites a very great Fire.

237. The Heat of the Fire acts the stronger upon the Bodies to be changed, as the Muffle put in the Furnace is less; as the said Muffle has more and larger Segments cut out of it; as the Sides of this Muffle are thinner; in short, as there are more Vessels placed in the hinder Part of the Muffle; and on the contrary.

238. In this Case, when many of the Conditions requisite for the exciting of Fire are wanting, then indeed the Artificer, with all his Skill, will hardly be able to excite the Fire to a sufficient Degree, in order to perform Operations well, in common Assay-ovens, even though he uses Bellows, and puts Coals into the upper Door of the Furnace. For this Reason, I have put the Grate almost three Inches below the Muffle, lest the Air rushing through the Ash-hole, should cool the Bottom of the Muffle which

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happens

happens in common Assay-ovens; and again, that the smaller Coals, almost already consumed, and the Ashes, may more easily fall through the Interstices of the Grate, and the larger Coals still fit to keep up the Fire, be retained. Finally, I have added the Funnel (*Plat. III. Fig. I. t.*) that the blowing of the Fire being, by means of it, increased as much as possible, this might at last be carried to the requisite Degree: For the Fire may always be diminished, but not always be increased at Pleasure, without the Assistance of a proper *Apparatus*.

239. The other Furnace necessary to the Assayer is called a *melting Furnace*, and is likewise compacted of Iron Plates. The Cavity of it may be formed according to the elliptical Mould (*Plat. III. Fig. V*). 1st, Make an hollow Ellipsis, the Focus's 12 Inches asunder, and the Ordinate 5 Inches long; cut it off in both its Focus's, that it may assume the Figure (*Plat. III. Fig. VI*). 2^{dly}, Then make in this hollow Body, and near its lower Aperture, four Holes, eight Lines in Diameter, and directly opposite (*c c*). 3^{dly}, Then fasten two flat iron-Rings (*d*), almost one Inch and a half broad, at both the upper and the lower inward Edge of this oval Cavity; and fill the Inside of it with small iron-Hooks, jutting out about six Lines, and three or four Inches distant from each other. These, together with the Rings just mentioned, serve to fasten the Lute. Thus will the Body of the Furnace be made: Only you must add at the outside two iron-Handles (*e e*), to be rivetted on each Side of it, that it may be taken hold of and moved. 4^{thly}, Then make the Cover of the Furnace, which may be formed like the Part cut off from the Ellipsis (*Fig. V. a*. See *Fig. VII*). Let this have an opening (*b*) made in it, four Inches high, five Inches broad at bottom, and four Inches at the Top; and adapt to this an iron-Door hung on Hinges to shut it close, and having at the Inside a Border fastened to it, answering exactly to the Circumference of the Door, and as prominent inwardly

as the Thickness of the Lute to be applied to it requires: (see *Fig. VIII*). For the same Purpose, let small iron-Hooks be fastened to the Inside of this Door, which is intercepted by the said Border. And lest this Cover should be burnt within, by the Force of Fire; you must cover the Inside of it over with the same Lute mentioned before (§ 233.) for the Assay-oven: Therefore it must likewise be furnished with a Ring and iron-Hooks to fasten the Lute; as was said before (N^o 3.) when we spoke of the Body of this Furnace. Besides this, you must fasten two iron-Handles (*Plat. III. Fig. VII. c c*) on the outside of this Cover. Then a round Hole must be made in the Top of it, being three Inches in Diameter, prolonged into a hollow Tube (*d*) almost cylindrical, and a few Inches high, upon which the iron-Funnel described (§ 232. N^o 8.) may; in Case of Necessity, be put after the Manner mentioned in the same Place when we spoke of the Assay-oven. 5^{thly}; After this, the Lining of both the Body and Cover of the Furnace within is made in the same Manner above described (§ 233). Moreover, you must make for this Furnace two moveable Bottoms, *viz.* One to receive the Ashes, and admit the Air; the other to serve for Reductions. The first is made with an Iron Plate, formed into a hollow Cylinder, open at Top, and to be shut at Bottom with an orbicular iron-Plate, as with a Basis, five Inches high, and of such a Diameter, as that it may receive the inferior Orifice of the Body of the Furnace (N^o 2.) the Depth of half an Inch (See *Plat. III. Fig. IX.*) Therefore let an iron-Ring (*e*) half an Inch broad, be fastened on the Inside of the said Bottom, and at the Distance of half an Inch from its upper Border, to support the Body of the Furnace put into it. Again, let this Bottom have a square Door, four Inches high, and as many Inches broad; that may be shut closely with a Door hung on Hinges, that you may by means of it increase or diminish the Draught of the Air, and thus govern the Fire at pleasure. Then, on the left Side of this

Door, and at about half the Height of this bottom Part let a round Hole be made, one Inch and a half in Diameter, to admit the Pipe of the Bellows when Need requires. Next to this, let another bottom Part be made of the same Matter and Figure as the foregoing: Let it be likewise of the same Diameter, but two Inches higher, so that it may be of the Height of seven Inches. Likewise let it have round it a like iron-Ring below its upper Border, to support the Body of the Furnace to be received in it. But let a Hole two or three Inches broad, and one Inch high (*Fig. X. c*), be cut out just below this Ring, in the Side of this bottom Part. Then let another round Hole be made in the left Side of this first Hole, fit to admit the Pipe of the Bellows (*d*). Further, let another round Hole like the foregoing (*e*) be made on the right, and at the Distance of one Inch from the Bottom. Then let the whole Inside of this bottom Part (the Part above the Ring excepted) be overlaid with Lute, and a Bed be made at the Bottom, of a Figure like that represented by the Line (*f g b*). The Matter of which this is made, is common Lute pulverized, passed through a Sieve, and mix'd with such a Quantity of Dust of Charcoal, sifted in the same Manner, as that the Mixture being moistened in the same Manner as the Ashes (§ 178), and pressed down, may at least be lightly coherent. Of this Matter pressed on the Bottom of the bottom-Part, a Bed is made, like a Segment of a Sphere, having in the Middle a small Cavity somewhat lower, and made extremely smooth, after the Manner mentioned before (§ 184.) when we spoke of large Ash-Vessels or Tests.

240. This Furnace (§ 239.) is chiefly fit for Fusions, which may be made in it with and without Vessels. When you are to melt with a Vessel, put the Body of the Furnace (*Plat. III. Fig. VI.*) upon the first Bottom (*Fig. IX.*) that has a Door to it to open on Hinges; introduce two Iron Bars (*Fig. XI.*) through the Holes of the Furnace (*Fig. VI. c c*) put upon

upon them the iron-Grate (*Fig. XII.*) which you are to introduce through the upper Mouth of the Furnace: Then put in the Middle of this Grate a *Brick* or square *Tile*, very smooth every where, warmed, and perfectly dry: Otherwise the Vessels put upon it, especially the large ones, are easily split by the moist Vapours coming out of it in the Operation. Let the Height and Width of this *Stone* be a small Matter broader and higher than the Bottom of the Crucible or Pot to be set upon it: For if it were less high, the Bottom of the Vessel could not be sufficiently warmed; and if it were less broad, the Vessel might easily fall from it. Then put upon this *Tile* the Vessel containing the Matter to be melted, and surround it immediately with Coals on every Side, which must be ranged according to the Method prescribed before (§ 234). Then you govern the Fire, by opening and shutting the Door of the Ash-hole (*Fig. IX. b*): You excite it by putting the Cover (*Fig. VII.*) upon the Body of the Furnace; and if besides you put the Funnel (§ 232. N^o 8) upon the cylindrical Mouth (*d*) of this Cover, the melting Fire becomes still more violent. But if you moreover introduce the Bellows through the Hole of the bottom Part, (*Fig. IX. d*), and the joint of the Furnace with the bottom Part, and the Door of the Ash-hole, unless it can be shut very close, being exactly stopt with thin Lute [*or Windsor Loam*] the Fire thus excited by the blast of the Bellows is carried to the highest Degree, and far surpasses that which may be made in a Smith's Forge. Another Advantage of this Method is, that the Vessels are not so easily broken, because the blowing of the Bellows cannot affect them immediately, and because a Fire perfectly equal is excited on every Side. One may easily examine with this *Apparatus*, how *Stones* are affected by the Violence of the Fire only. Now, if you have a mind to perform any Operation without a Vessel, and with a naked Fire; for Instance, to melt and reduce the *Calxs* or *Scorias* of *Copper*, *Tin*, *Lead*, and *Iron*,

or the Oars of these Metals; the Body of the Furnace must be put upon the other Pedestal, having a Bed in it (*Plat. III. Fig. X*). However, you must before this open with a Knife the oblong Hole (*c*), and the round one (*d*) of this bottom Part, which are stopped with the Lute sticking to the Inside. Then you apply at the round Hole (*d*) on the left the Bellows, in such Manner that the Nozel of it being directed obliquely downwards, may blow strongly against the Bed (*fg b*); By this Means, all the Ashes that fall into the Bed are blown away, and the Strength of the Fire determined to such a Degree, that all the melted Bodies that fall into the said Bed, remain in their State of Fusion; And were it otherwise, the melted Bodies would immediately wax cold, and adhere in Grains to the Bed, whereas they ought to have melted into one *Regulus*. The oblong Hole in the fore-part of this bottom-Part (*c*) serves to discover by means of a Poker, whether the Matter in the Bed be melted, or not: It serves likewise to take away through it whatever might stop the Bellows, and in some Cases to take away the *Scoriae*. Then you put first Coals into the Furnace, one Span high, and blow them well with the Bellows, to make them burn, that the Bed may be very hot before the Matter to be melted is put into it: For if this is not previously done; the melted Mass seldom runs into a *Regulus*, but remains dispersed among the *Scorias* which soon grow hard. The Bed being well heated, and fresh Coals added to the Fire, put into it such Quantity of the Matter to be melted as cannot hinder the Fire from being carried to the requisite Degree: Which cannot be determined otherwise than by Experience; Again, put fresh Coals, and upon them another Quantity of the Matter to be melted; they may be like *Strata* one upon another. But if the Mass once melted could not long sustain the Strength of the Fire; or if you had a mind to melt a greater Quantity of Matter than what can be contained in the Bed; you must open the round lower Hole (*Plat. III.*

Fig.

Fig. X. e.) that you may make a Channel passing from that Hole through the Lute, and reaching to the small Cavity at the Bottom of the Bed (*g*): To this Hole at the outside, apply an earthen Dish like the Bed within, or any other proper Recipient, surrounded with burning Coals, into which the Matter melted running from the Bed through the Hole (*Fig. X. e*) may be collected (*Fig. XIII. i*). The other Particulars hereto belonging, and to be observed in special Cases, will be more easily recited, when we come to the Operations hereafter to be explained in the practical Part of Assaying.

Scholion. In determining the inward Figure of the Furnaces which are employed to carry the Fire to the highest Degree of Strength, you must not be so strictly exact in giving it such a Figure, as that the reflected Rays of the Fire may all be collected in one certain Point or Line. For the Matter wherewith the Furnaces are lined within, can never assume so smooth a Figure: Nay, if this Matter might assume it by any Art, it would soon be spoiled again by the Violence of the Fire. Besides, the Rays of the Fire cast by the Coals, do not fall with the same Regularity as those of the Sun and of Sound; nor can they of course be so exactly reflected towards the Body to be changed, or the said Matter itself being naked, is most commonly covered all over with Coals. On the other Hand, a Focus collected within so small a Compass, would be of almost no Service; because it can act only upon a very small Part of the Body to be changed. It is then enough to give the Furnace such a Figure and Size, as that it may 1. admit a sufficient, though not superfluous Quantity of Fuel for the Fire: 2. That it may confine the Heat of the Fire, so as that it may neither act with too much Liberty, nor be dissipated before it has acted strongly enough upon its Subject: For which Purpose some Sort of Cover must be added.

241. The Furnaces hitherto (§ 231 to 240) described, are sufficient for the performing of docimastical Operations strictly so called. But the Assayer must also perform other Operations, subservient to

the foregoing: Such are the Distillation of acid Spirits, Cementations, Calcinations, &c. which cannot be conveniently done in the Furnaces above described: Therefore, as these Operations most commonly want a long and constant Fire; it will be very proper, for this Purpose, to construct a Furnace called an *Athanasior*, which can contain as much fresh Fuel as will keep up the Fire for many Hours together, and admits of a different, an accurate, and most constant Regimen of the Fire.

242. Let then, 1st, a small square hollow Tower (*Plat. IV. Fig. I. a a a a*) be constructed of such Stones, [or of Bricks made of *Windsor Loam*,] as may resist the Fire; let the Sides of it be six Inches thick, and forming a square Cavity within, of ten Inches on each Side (*b b b b*). The height of it is determined, according as it is to keep up the Fire long, without any Addition of new Fuel: Five or six Foot are most commonly sufficient *. 2. At the bottom of this Tower make an Opening (*c*), six Inches broad and as many Inches high; hang to it an iron-Door, being on every Side one Inch broader than the Opening, and such as may shut it very close: For which Purpose the external Edge of this Opening must be excavated all round in such Manner, that it may form a Groove one Inch broad, into which the Edges of the Door may be received. 3. At the distance of ten Inches from the Bottom of the Tower, put a Grate (*d*), made of prismatical, quadrangular iron-Bars, one Inch thick, and three quarters of an Inch distant from each other: Let also each of these iron-Bars, be so situated with regard to the Tower, that the two opposite acute Edges of each may look perpendicularly, one downward, the other upwards, that, by this Means, the Ashes may easily fall into

* These Towers may likewise be made of cast Iron, in form of a truncated Cone, six Inches diameter in the Clear within at top, and twelve at bottom, made with a Groove round the Top for an hemispherical Cover to be put upon it; and the Bottom of the iron-Tower must be set upon the Stone or Brick-work, just above the Opening at (*e*) described at N^o 4.

the Ash-hole. 4. Make above this Grate an Opening circular at Top (*e*), six Inches high, seven Inches broad, that may, as well as the Ash-hole (N^o 2), be opened and shut with an iron-Door. 5. Adapt to the Top of the Tower an iron Cover (*f*), exceeding the Aperture of the Tower all round two Inches, and having a Handle, wherewith it may be easily taken away, and put on again. Thus you are to make the Furnace called in *Latin Furnus primarius*. 6. Then cut out in any Side of the Tower, for Instance in the left, an oblong square Aperture, going up obliquely toward the outside (*g g*), four Inches and a half high, ten Inches broad, having its inward inferior Edge, one Inch and a half, or two Inches above the Grate (*d*), that, by the intervening of this Hole, the Cavity of this Tower may communicate with another immediately to be described. 7. Nearly over-against the same Side of the Tower, make a Cavity with Stones, whose inferior Part must be a hollow Prism (*Plat. IV. Fig. 1. b b b b*), six Inches high, twelve Inches broad, ending at Top in a Semi-cylindrical Arch (*i i*) described by a *Radius* of six Inches; that by this Means, the Height of the whole Cavity be twelve Inches in the Middle. Let this anterior Cavity be totally open, though, when requisite, to be shut very close with an iron-Plate (*k k k*), whose inward Surface is to be constructed, in the same Manner prescribed (*Plat. III. Fig. VIII.*) for the sliding Door of the melting Furnace, and then luted two Inches thick within. Moreover, let there be in the Middle of this Plate, a round Hole (*Plat. IV. Fig. 1. l*), four or five Inches in Diameter, and let the Circumference of this Hole have an iron cylindrical Border made to it, and prominent within; that by means of it, the Lining of Lute within may be supported, and kept from falling down easily. Let a Notch one Inch broad, and two Inches deep, be made in the outward Circuit of the Aperture of this Cavity, to receive the Extremity of the Plate that shuts the Aperture. The Hole of this Plate (*l*) either is shut with a Stopple (*m*),

(*m*), or serves to pass the Neck of the Retort through. This Plate likewise is fastened with two Bolts (*nn*); to be put horizontally with the iron-Hooks (*oooo*), driven into the Wall near the Edge of the Aperture, so that one Bolt may fasten the upper Part of the Plate, and the other the lower. 8. It is moreover proper, that the square Aperture (*gg*), through which the Fire enters from the Tower into the Cavity hitherto described (N^o 7.) may be shut and opened at Pleasure with an iron-Slider: For if this is not done, an excessive Fire, employed sometimes by an unexperienced Hand, cannot be so easily checked. For this Purpose, let a Slit half an Inch broad, and eleven Inches long, be left in the Wall that constitutes the upper Part of the Cavity (N^o 7), and is contiguous to the Tower; so that it may exceed the Length of the square Aperture (*gg*) a small Matter on every Side, and reach before and behind into the small Grove, going down along the perpendicular Sides of the said Aperture (*gg*), and retain the iron Slider to be put into it to keep it steady. However, let this iron-Slider (*6*) be six Lines thick, eleven Inches broad, and five Inches high; and let a Couple of small iron-Chains (*pp*) be fastened on each Side of its upper Edge, wherewith the Slider may be lifted up and let down again. Therefore, let a Couple of strong iron-Nails ** be drove into the Contiguous Wall of the Tower, perpendicularly over those Places, in which the said small Chains are fastened to the iron-Slider, that any of the Links of the Chains may be suspended on them at Pleasure. Moreover, let the upper Edge of the Slit above described be entirely shut up with Stones and Cement, leaving only two small Holes through which the small Chains may be passed. 9. On the left of this (N^o 7.) Cavity, and at the Distance of eight Inches from the Bottom of it, let a square (*qqqq*) Chimney or Funnel be erected with Bricks, three Inches and a half in the clear, four Foot high, and a small Matter convergent upwards, so that the Diameter of it at Top may be three Inches. This Funnel must be contrived to be

shut closely with an iron-Slider, having a Handle to it (*rr*), which Slider must move freely between a double iron square Frame (*ssss*) fastened in the Walls of the Funnel, at such a Height from the Hearth as shall seem convenient to any Artificer.

10. Blow this Chimney, let a square Aperture be made, like the foregoing (N^o 6 (*gg*), leading obliquely up to the Bottom of another cylindrical Cavity (*uuuu*), which is eight Inches deep, described by a Radius of six Inches, open at Top, and there converging inwardly into a Border one Inch thick, and six Lines broad, designed to support an iron-Pot. Likewise, cut in the anterior Wall of this Cavity, and at the upper Part of its Mouth, a Segment two Inches and a half deep, five Inches broad, and stooping forward (*vv*), to receive the Neck of a Retort.

11. To this Cavity (N^o 10.) belongs an iron-Pot (*ww*), eleven Inches broad, and about nine Inches deep, which must be encompassed with an iron-Ring (*xx*), one Inch broad, and fastened at the Distance of one Inch and a half from the upper Edge of the Pot. Let a Segment (*y*) be likewise cut off the upper Edge of this Pot, which Segment must be four Inches and a half deep, and five Inches broad: The iron-Ring just described must be bent all round the Edges of this Segment.

12. Over against the Aperture (*tt*) which communicates from the first Cavity (N^o 7.) into the second (N^o 10.) let another such Aperture (*z*) be made two Inches distant from the Bottom of the second Cavity (N^o 10.) perfectly like the foregoing (*gg tt*), and communicating obliquely upwards with a third Cavity (*iiii*), like, and equal to the second cylindrical Cavity (*uuuu*); that the Fire may pass from the latter into the former.

13. In the hinder Part of the Wall which makes the Aperture just mentioned (*z*), let a Chimney like the foregoing (*qqqq*), and of the same Height (*2222*) be erected, that may be shut with a Slider like that (*3*).

14. Finally, on the left Side of the third Cavity (*iiii*) let an Aperture be made in the same Manner

ner (4), and like the foregoing ones (*g g t t z*) more remote however from the Bottom of the Cavity, without a Passage at the other Extremity, and communicating only with the Cavity of the third Chimney (*5 5 5*), which must be erected in the same Manner as the two foregoing ones (*q q q q. 2 2 2 2*). Thus you will have a Furnace very proper for a great many Operations.

243. We are now to speak of the use of the *Athanaor* just described (§ 242); and chiefly to mention, to what Operations each of its Parts serve in particular, and then how the Fire may and must be governed in it. 1. You must put at the upper arched Door (*e*) of the Tower, a Semi-cylindrical Muffle twelve Inches long, which must be introduced through the Door: Which for this Reason must be of the same Height and Breadth as that Door, three Quarters of an Inch thick, and open behind, being shut there by the hinder Part of the *Athanaor*, as far as which it must reach. For this Purpose, a *Tile* must be set upon the Grate (*d*) to support the Muffle. Let also this Muffle have small Pieces cut out near its Basis, as common Assay-muffles (*Plat. II. Fig. I. and II.*) You may put under this Muffle your Cement Pots, or such Bodies as must be calcined with a long violent Fire: Which can be done without a Muffle, though not so neatly. 2. In the first Chamber (*Plat. IV. Fig. I. b b b b i i*) you may make the most violent Distillations with an open Fire: For Retorts or large Vessels are introduced into it, after you have taken away the Door (*k k k*), and are put either upon the Hearth itself of this Chamber, or upon a particular Support of Stone. But you must place these Vessels in such manner, that their Necks may easily pass through the Hole (*l*) of the Door, when put on again: For which Purpose, they chuse a Support sometimes higher, sometimes lower, according to the different Heights of the Vessels. When afterwards the Door is put on again, and fastened with both its Bolts (*n n*), you must close with Lute all the Chinks which lie open

open about the Neck of the Vessel, and between the Edges of the Door and the Entrance of the Chamber. Then you apply to the Neck of the Vessel a cylindrical Segment, ten or more Inches long: By means of which the Heat and the boiling Vapours coming forth are gradually diminished; lest the Recipient, which is always chosen a Glass Vessel, should split. The Recipient, which must be united with the other Orifice of the said Segment, is supported either by the Pavement, or by a certain kind of Trivet, the Construction of which is such, that it may be set lower or higher by means of three Screws. 3. In this same Chamber, instead of Distillations, you may also make Cementations, Calcinations, &c. In which Case the round Hole (*l*) of the iron-Plate may be shut and again opened with a Stopple (*m*), that one may view the Inside. 4. The second and third Cavities (*uuuu. i i i i*) serve chiefly to such Operations as are made in Baths [or Beds] of *Sand*, *Asbes*, or *Filings*. For Instance, you put into each of these Cavities a Pot (*w*) and you stop with thin *Lute* or with *Sand*, which must previously be moistened, the Slit between the iron-Ring (*xx*), and the Border of the Cavity, upon which this Ring rests. 5. Besides, you may also make in these two Cavities, Distillations by a reverberating Fire, as well as in the first: Only the Fire is less violent in these, though sufficient to extract *Aqua Fortis*. You then take out the iron-Pot (*w*), and inverting it, you put it upon the Mouth of the Chamber; so that the Brim of the Pot, being the Depth of one Inch and a half above the iron-Ring (*xx*), wherewith this Pot is surrounded, may be received within the Mouth of the Cavity, and so that the Segment cut in the Pot (*y*) may, together with the Segment cut out from the Side of the Cavity (*v v*), form a Hole to let the Neck of the Vessel through. 6. All the *Apparatus* being thus ready; you first introduce through the Top of the Tower (*b b b b*), a few burning Coals: And put upon them some of the unkindled Fuel of the Fire; that the Cavity of the Tower may, according as it is

thought

thought necessary, be filled either entirely or only in part. Then with all Speed you put upon it the iron-Cover (*f*), and strew the Border of this on the outside, with *Sand* or *Ashes*, which you press gently with your Hands: For if you should neglect this Point, all the Fuel contained in the Tower would be kindled, and may endanger setting the House on Fire *.

244. We shall here annex a few general Rules concerning the Regimen of the Fire in this Furnace: For it is hardly necessary to explain all Particulars, since Practice will easily hint them to such as shall be ever so little acquainted with Chemistry. The Fire may be made very strong, in the first Chamber (*Plat. IV. Fig. I. b b b b i i*), when the Door of the Ash-hole (*c*), and the Funnel (*q q q q*) of the Chamber is quite open, and when the iron-Slider suspended with Chains (*6. p p*) does not hinder the Fire from passing freely from the Tower into this Cavity. But the closer the Funnel is shut, together with the Door of the Ash-hole; the more the Violence of the Heat diminishes: And this will be soon effected, if the iron-Slider suspended with Chains, is let down in part: For the Fuel contained in the Tower, burns at least as high as the Space between the lower Edge of the iron-Slider and the Grate (*d*). Observe besides, in those Operations, wherein the round Hole (*l*) of the Door is stopt with a Plug (*m*), that when the strongest Fire is required, this Hole must not be kept long open: Because the Air rushing violently through it, soon cools the Bodies put into the Cavity. The Operation mentioned (§ 243.) may be performed in the second and third Chamber, in, and at the same Time, and with the same Fire, as they are in the first Chamber: For the Fire penetrates from the first Cavity into the second, and increases when the Funnel (*2 2 2 2*) erected on it is opened. But before you

* Therefore the iron-Tower mentioned page 88. is more safe, because the Groove at top may be filled with water, or Lute mixt very thin with water, which will effectually hinder any air or smoak from getting through.

So this, the Funnel of the first Cavity must be shut as much as that of the second is opened. By the same Means, you may hinder the Fire, which serves for the Operations made in the two first Cavities, from going out through their Funnels, and you force it out, on the contrary, through the third Cavity and through its Funnel (5 5 5); that it may also act upon the Bodies placed in that Cavity. For the more the Funnel erected upon the third Cavity is open, the more one or even both Funnels of the other two Cavities must be closed. Thence it is plain, that you cannot kindle the strongest Fire in the third Cavity, unless there be one equally strong in the other two; and that on the contrary, the Heat in the third Cavity may be rendered less, by closing its Funnel; though it be violent in the others. The same is true of the second Cavity, with regard to the first. Finally, you cannot make the strongest Fire under the Muffle placed within the upper Door (*e*) of the Tower, unless you have an equal Fire in the first Cavity, which Fire may consequently be increased, by shutting the Door quite against the Muffle (*e*), and diminished by opening it; there being mean while an equal Heat in the first Chamber, and in the following ones. The rest will easily be learned by Practice.

III. Of the other Utensils of Assaying.

245. Assayers make use of four Sorts of Tongs. the first (*Plat. IV. Fig. II.*) consists of two iron-Legs, two Foot long, as many Lines thick, joined together in the Middle with a Rivet (*a*), so as that they may be shut and opened steddily. Let the fore Part of these Legs wherewith the Vessels are laid hold of, be curved on the inside (*b*) into a Semi-lunar Figure; and let the hinder Part have two Rings (*c*) to manage the Tongs with. This Tool serves to draw the Tests and smaller Crucibles out of the Furnace.

246. The second kind of Tongs are made of a Plate of *Steel*, hardened to a Spring-temper. Let them be six Inches long, almost sharp in the fore Part, and

and well polished (*Fig. III*). With these you take up the metallick Grains remaining in the Coppels, and other minute Bodies.

247. The third kind of Tongs (*Plat. IV. Fig. IV.*) are adapted to melting Crucibles of a middle Size, three Foot long, having very strong Legs, and as to the rest made like the first (§ 245); except that each of the Legs must be bent downwards at their Extremities, into a sort of Beak, some Inches long, and one Inch and a half broad; that the Sides of the Crucible being squeezed fast between these, it may be held steddily. These Tongs are chiefly used, when Metals melted in Vessels of a middle Size, are to be poured out into Moulds or Ingots.

248. The largest Vessels, containing a great Quantity of Metal, are more easily cracked in the Fire than the small ones; and their Cracks, if they do not proceed from the Moistness of the *Tile* set under them, are always found in the higher and larger Part of the Vessel, and most commonly run from the Top towards the Bottom, seldom transversely. To be able to take such Vessels safely out of the Fire; you must have Tongs stronger and longer (*Fig. V.*) than the foregoing (§ 247). Let one of their Legs be curved a small Matter at the End, and end in a strong Semi-circle eight Inches in Diameter, and so fixed, as that it may make half right Angles with the Leg of the Tongs (*a*): Let the other Leg be curved in the same Manner at the End, and have at its Extremity two Semi-circles like the foregoing, but so situated among themselves, and with regard to the foregoing, that they may be distant from each other about one Inch, so that there may be a Space in which the Semi-circle of the other Leg may be received (*b*): The Effect of this Structure is, that small and large Vessels may be managed with them. The Vessel to be taken out, is laid hold of a little below its upper Border, with the curved Extremity of these Tongs, which must be first heated just red hot in the Fire; and being thus surrounded with a whole Circle, is safely taken out of the Fire.

249. When

249. When the Matter put into small Vessels is to be stirred; you must make use of an Iron-Hook, two Foot long, and one Line and a half thick (*Plat. IV. Fig. VI.*). It is proper to have two or three of these Hooks; that is, as many as there are Vessels together under the Muffle, with the Matter to be stirred; that you may not be obliged to use the same Hook to stir them all, and that the Matter in one Vessel may not be spoiled by Particles of that of another, which may happen to stick to the Hook: For you have not always Time enough to beat off with a Hammer, or to file off the adhering Particles.

250. When Ashes must be removed from the Convexity of the Muffle; or when Vacuities and Interstices happen to be between the burning Coals, that render the Fire unequal; you sometimes introduce into the Hole of the Assay-oven (*Plat. III. Fig. I. p*) an Iron-Rod (*Fig. VII.*), wherewith you throw the Ashes down, and make the burning Coals fall together.

251. The Matter in the Crucible is to be stirred with the Iron-Hook (*Fig. VIII.*)

252. When Operations are to be made in the larger kind of Tests, it is proper to have a stirring Iron (*Fig. IX.*) four Foot long, with which you either stir the Mass, or take out the more clammy *Scoria's*.

253. When the Grates are stopped, you clear them with the Hook (*Fig. X.*) the Size of which is self-evident.

254. The small Iron-Ladle (*Fig. XI.*) six Lines in diameter, well polished, and having a Handle two Foot long, serves to put Bodies, which must be previously broken small, into the Vessels, especially such Vessels as are under the Muffle. You must have a larger hollow Ladle, whose Figure is sufficiently known, to melt *Lead, Tin, &c.* in a gentle Fire.

255. A strong Fire, if you look at it too long, not only dims your Eyes, but also hinders you from observing distinctly the several Changes of the Bodies. To remove this Inconveniency, you must provide a small Board, made of the driest Wood, and one Foot

both in Length and Breadth; that it may screen your whole Face. It has a Handle one Foot and a half long: And a Slit is cut in the Middle of it horizontally, one Line and a half broad, divergent towards the other Side of the Board, to be turned against the Fire, and sufficiently extended each way; that there may be a larger Field for Vision, and both Eyes may at once easily distinguish the Objects. We will call this Instrument a *Screen*, through the Slit of which the Workman may see, without any Apprehension from the Fire, or from the Sparkles that fly, and thus safely contemplate his Object. (*Plat. IV. Fig. XII.*)

256. To kindle the Fire, you must, besides the small Hand-Bellows, have a larger *double Pair of Bellows*, three Foot long (*Plat. V. Fig. I.*), such as are used by Goldsmiths and Farriers. Let them be supported by a wooden-Frame, so well fitted, as that they may at Pleasure be raised up, and let down before and behind, about the Height of one Foot. The Structure of this Instrument is sufficiently known, from the above-mentioned Figure. If these Bellows lie by unused, they must be kept stretched, and every Quarter of a Year rubbed with Neat's-foot or Train Oil: for, this being neglected, the Leather cracks soon, and the Ligaments grow stiff; which occasions a weak and unequal Blast.

257. Some, instead of Bellows, use an *Eolipyle*, which is a hollow Ball, made of a Plate of Copper, and about sixteen Inches in Diameter, having an open Pipe coming out of it, in the Direction of a Tangent, and nearly such as is put on a large Pair of Bellows. If you set this Vessel two thirds full of Water, on the Fire, so that the Water within may boil strongly; and then direct the Aperture of this Tube towards the Fire to be blown; a Blast rushes out of it, and blows the Fire with great Force. However, you must forbear using this Instrument, when Copper is melted without a Vessel, and is collected in the Bed of the Furnace (§ 240): the
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more, because it is not uncommon to see large Drops of Water spouting out of the Tube of the *Eolipyle* *.

258. When small Pieces of Metal are to be melted; the best Way to do it, is to put them upon a hard Piece of Charcoal, with a small Hollow made in it; and then direct the Flame of a Lamp having a large Cotton, upon the small Mass of Metal to be melted, by blowing it thereon with a small crooked Pipe: For by this Means, *Iron* itself may be melted without any *Apparatus*: Which succeeds still better, by adding *Borax*. Let the Pipe, with which this is performed, be made of Copper, and let it have in its bending Part, a hollow Globe one Inch in Diameter, through which the Wind is to pass, that the Moisture of the Breath gathering into small Drops may be collected within the Cavity of this Globe, and not reach the small Flame, and hinder the Action of the Fire. Let the less Aperture of this Tube through which the Wind comes out, be so small, as to admit hardly the smallest Needle. This is called the *cementing Tube*, or *Blow-pipe*.

259. The *Load-Stone* is often sufficient to discover Iron: For want of this Stone, you must have Recourse, for that Purpose, to a long and tedious *Apparatus*. Therefore, the Assayer ought to be provided of one well armed, and keep it loaded in a dry Place.

260. You must likewise be provided of an *Anvil*, the upper Surface of which must be perfectly well polished, and about one Inch square, with a small Hammer adapted to it: Both these must always be kept perfectly clean, lest they should be spoiled by Rust and Dirt, and contract Furrows: Otherwise, if the Metal is vitiated, or any thing goes from it, it hinders many Operations, especially that Separation of *Gold* from *Silver*, which is called *Quartation*, and shall be explained in our practical Part.

* A very cheap and ingenious kind of Bellows have been newly invented by Mr. *Trievald*, Captain of Mechanicks, &c. to the King of *Sweden*, a particular Description of which is to be seen in *Philos. Trans.* N^o 448, to which I refer the Reader.

261. However, he that pursues the Art of Assaying, can never be without an Anvil, large Hammers, a Vice, Files, Wedges, &c. but these, being so well known, want no Description.

262. It remains, that we should examine and give an Exact Description of the *Assay Balance*, and the Manner of correcting the Defects of it; because it is an Instrument of the utmost Importance in docimastical Operations, and serves to determine exactly the Weights of minute Bodies.

263. Let this Balance be made of the best Steel: For it may be constructed much better of this Metal, which must be of the hardest Kind, though sufficiently tractable, than of any other Matter. Besides, Steel is not so easily spoiled with Rust, as Iron; and it is more apt than other Metals to take a perfect Polish, which at the same Time prevents the Rust. Meanwhile, let the Steel to be employed for this, be tempered a little softer than a perfect Spring; that it may return to its State, when slightly bent; for it cannot then easily contract Faults, and if it does, they may be easily mended.

264. The Structure of the Assayer's Scales is hardly different from that of common Scales, otherwise than by its Nicety and Smallness. The longer the Beam of it (*Plat. V. Fig. II.*) is, the more small Faults will be sensible in it: Therefore, the longer must be preferred to the shorter. However, ten or twelve Inches are a sufficient Length. Let the Thickness of it be so very small, that two Drachms may hardly be hung at either of its Extremities (*a b*), without its bending. For the largest Weight put upon it seldom exceeds one Drachm. The whole Surface of this Beam must be altogether without Ornaments, which do but increase the Weight, and gather Filthiness. The Beam is suspended in a Fork (*Fig. III.*) the two Legs of which are steel-Springs joined at Top, but kept together below with a brass, pliant Clasp (*Fig. IV*) parallel, and two Lines and a half distant from each other. This Clasp being taken off, and
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the Legs of the Fork being stretched out, the Axis of the Beam may be put into two Holes (*aa*) made for that Purpose at the Ends of the Legs, or be taken away from them. Let a very sharp Needle (*c*) be fixed in the Head of the Fork, standing perpendicularly downwards, if the Fork is suspended, and so long, as that it may almost touch the Top of the Tongue of the Beam (*Plat. V. Fig. II. c*) put into the Fork, when in *Equilibrio*. This Needle is the Mark of the *Equilibrium*; and that the Artist, who stands over-against it, may be able to observe this, the Legs of the Fork must be broader in that Place, and have an Opening two or three Lines (*d*) wide. However, this Fork may be adorned at Pleasure; provided the Motion of the Balance is not hindered by such Ornaments. Then take two Scales made of a thin Plate of *Silver*, almost flat, one Inch and a half in Diameter, hanging on three small silk-Strings, almost as long as the Beam, tied together at Top with a *Silver* Hook, in form of an S, and hang them to the Extremities of the Beam. A smaller * silver Dish, somewhat less than one Inch in Diameter, belongs to each of these Scales (*Fig. V.*) You first put into these Dishes, with a Pair of Pincers, the Bodies to be weighed, or with a Spoon or a small Shovel, when they are pounded, and then you put them into the Scales: Therefore the small Dishes must be perfectly equal in Weight. We use them, that Bodies may be more conveniently put into and taken out of the Scales, and that these, which are vastly thin, may not be bent, soiled, and so be rendered false by wiping.

265. This Balance (§ 264.) is suspended on a moveable Brass or Copper-Support, which consists of a Pedestal (*Fig. VI. a*), and of a Column set upon it (*b*) about twenty Inches high, at the Top of which comes out a right Angles an Arm (*c*) one Inch long. At the Extremity of this Arm, put a small Pully (*f*)

* Or if made of Steel blued over Charcoal they are less apt to wear.

three Lines in Diameter: Put another at the Top of the Column (*e*), and a third near the Bottom of it (*d*): All which Pullies must turn very easily on their Axis. At the Distance of one Inch and a half below the upper Arm, let another Arm one Inch and a half long (*g*) come out of the Column at right Angles, having a Hole through it (*b*) two Lines long, a quarter of a Line broad, and placed perpendicularly below the Pully of the upper Arm (*f*), to receive a small Plate (*i*), one Inch and a half long; and of such Breadth and Thickness, as that it may freely move up and down, and yet not have too much play within the Hole. Moreover, let this Plate have a small Hook at each Extremity.

266. And as such a Balance is very ticklish, and will hardly stand still in the open Air, and becomes false, when spoiled with Dust: It must be put, together with its Support, into a small Case, having Glasses at Top and all round it, that you may see what is within. The Size of such a small Case is evident; and must be such, as that the Balance suspended on its Support, may be conveniently placed and turned in it. The Windows of the right, left, and fore Sides of it, must be made in such Manner, that they may be opened and shut without any great shaking of the Case. The Basis of it must be a Draw, two Inches high, equal in Breadth to the Case, jutting out in the fore Part four or five Inches beyond the Front of it, and easy to be drawn out and thrust in again. In this Draw you must put the Weights, inclosed in their little Partitions, a small Pair of Pincers, a small Shovel, or a Spoon, wherewith to put the Powders into the small Dishes of the Scales, and other Things, if any are requisite: By which Means, you will have all these Instruments at hand, and keep them perfectly clean (See (*Plat. V. Fig. VII.*))

267. The *Apparatus* we have hitherto described (§ 263—266, is disposed for use in the following Manner. Pass a Silk String over the three Pullies of the Support (*Fig. VI. e f d*), and tie it at its upper Extre-

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mity to the small Hook of the Plate (*i*), which is then introduced into the Hole of the inferior Arm (*b*). Then you put the Support (§ 265.) in the Middle of the small Case (§ 266), and you pass the other Extremity of the silk-String below, through a Hole bored in the Middle of the lower Border of the Frame, containing the Window in the fore Part of the Case, and fasten it to a Weight of a few Ounces (*K*), reduced into a cubick Form. Next to this, you must suspend the Fork of the Balance (*Fig. III.*) on the inferior Hook of the Plate (*i*) *Fig. VI.* By this means, if you move backwards and forwards the Weight fastened to the String (*K*), placed upon the Top of the Draw, that juts out beyond the fore Part of the Case, the Balance within is either lifted up, or let down. But you must put the Bodies to be weighed, and the Weights themselves in the small silver-Dishes (*Fig. V*), and you put these, when loaded, into the Scales, through the side-Windows, which must be opened for that Purpose. When any thing is to be added to, or taken out of them, you do it with the small Pincers, or, if it is Powder, with the small Shovel or Spoon. However, you must let the Balance down, every Time any thing is to be added, or taken away; that the Scales may rest upon the Bottom of the Case: But then you must shut the Windows, before the Balance is lifted up again, especially if the Air is not perfectly calm (*Plat. V, Fig. VII.*)

268. To see whether the Balance (§ 264.) is just, or no, you must interchange the small Dishes. That is, you first put the said Dishes into the Scales, and lift up the Balance, to see whether it is in *Equilibrio*, or not: If not, you will procure the *Equilibrium*, by adding granulated Lead to the lightest Dish. This *Equilibrium* once obtained, you put the Dishes in the Place of one another, and again lift up the Balance: If it keeps still in *Equipoise*, it is a Sign of its being just: But if, after the Permutation of the Dishes, you no longer find the Balance in *Equilibrio*; it is a sure Sign of its being faulty. Moreover when, the Ba-

lance being elevated, you see the Beam moving in the Fork, not only up and down, but also side-ways, this likewise shews a Defect in the Balance. You must besides, reckon it one of the Faults of your Balance; if, when having lifted it up, and put it in *Equilibrio*, you lower one of the Scales with your Finger, and this does not return to its Equipoise, when the Finger is removed: If this be the Case, your Balance may indeed be right, as to the Length and Weight of the Arms of the Beam, but it can hardly be restored to an exact Equipoise, whence it is less fit to weigh any thing exactly.

269. But it is not enough to have known whether a Balance was just or defective: We must likewise be able to correct the Faults detected in it. You must then above all know the Causes of the Defects; that, by removing them, the perfect Exactness desired may be obtained. Nay, the Assayer stands in greater Need of knowing how the Faults of a Balance are corrected, than the Manner in which the Balance is made; because, by mending, he at last obtains the scrupulous Exactness requisite in docimastical Ponderations. Let us then take this Point in hand. First, it is a teasing Fault in a Balance, when it cannot either be reduced to a Situation perfectly horizontal, or, when being reduced to it, and either of its Scales being lowered, it is not immediately restored to its first State, by the Removal of the Power that lowers it. This shews that the Axis upon which the Beam of the Balance is supported, is in the same horizontal Line with those Points to which the Powers are applied. To correct this, take the Beam out of the Fork, and, with a Pair of Pincers, lower a little the ringed Extremities (*a b*) of the Arms, with such Evenness however, that a Thread, extended from one Ring to the other, along the Length of the Beam, may be on either Side at right Angles with the Tongue of the Balance, which must be proved by applying to it a Square. 2. But if the Balance, put in *Equilibrio*, does not easily change its Situation, with a very small

Weight added on one Side ; it shews, either that the Axis is not sufficiently acute, or that the Holes of the Fork in which the Axis turns, being too narrow, resist to the Motion of it ; or, in short, that the Axis is placed too high above the horizontal Line, drawn from one of the Rings of the Arms to the other. The two first Faults are very easily mended, by either sharpening the Axis or widening the Hole. As to the third Defect, as the Axis cannot be removed, the Rings must be elevated : Which may be done in the Manner mentioned (N^o 1). 3. It is a Fault in a Balance, when, being equipoised, it does not stand the interchanging of the Powers ; or if, the Powers being removed, it declines on either Side : This shews, when the Scales and Dishes are equiponderous, that either one of the Arms of the Beam is shorter than the other, or the one out-weighs the other, or that the Defect proceeds from both Causes. Therefore, to correct it, you must first lift up the Balance unloaded, and, if it is not in *Equilibrio*, let the Equipoise be restored, by putting Grains of Lead into the Scale. Then put the small Dishes into the Scales, and if the Balance does not remain in *Equilibrio*, let the *Equilibrium* be again restored by putting granulated Lead into the small Dish, not into the Scale. This done, if the Dishes can be interchanged, without altering the *Equilibrium* ; it shews, that you must take as much matter from one of the Scales, with a Whetstone or a File, as you have put Grains of Lead in the other, to obtain an *Equilibrium* : For one is heavier than the other : Which Inequality is most commonly occasioned by Dirt, or Rust. But if you cannot interchange your small Dishes, and preserve an *Equilibrium*, you may be sure that one or the other of the Extremities of the Beam, and even that which goes down after the interchanging of the Dishes, is more remote from the Axis than the other. Wherefore, this Arm must be made shorter : Which is done, by pressing softly, and a small Matter towards the

Axis,

Axis, with a delicate Pair of Pincers, the small ringed Bow which is at the Extremity of this Arm: Taking care mean while, not to raise or lower at the same Time the Extremity of the Beam: Otherwise it would be but substituting the first (N^o 1.) or the second (N^o 2.) Fault, to the Fault corrected. Therefore, this being done, take away the small Dishes, and, by taking something of the granulated Lead, which you had put before into the other Scale, restore the *Equilibrium*, which had been wanting all the while: For then the Arm of the Beam, which had been raised before, will certainly be lowered. Then again put the small Dishes into the Scales; and, if you do not find an *Equilibrium*, restore it, by putting granulated Lead into either of the Dishes; Which done, interchange the said Dishes; and you will see, from the want of *Equilibrium*, which of the Arms of the Beam is still longer than requisite: If you find it to be so; mend the Fault as before, that is, by shortening the lowered Arm, or by lengthening that which is raised, having always an Attention to the Cautions already prescribed. Repeat these manual Operations over and over, till the Balance, unloaded, and equipoised, either of itself, or by Means of granulated Lead put into either of the Scales, may undergo the interchanging of the small Dishes, without disturbing the *Equilibrium*: For then both the Arms of the Beam will be of equal Length. If after that, the first Defect, that consisted in the Inequality of the Scales, remains still, it may be removed in the Manner above-mentioned. The Causes of the other Faults, being more sensible, may of course be more easily mended: Therefore, we leave it to the Skill of the Artificer, to detect and correct them.

270. I shall, in favour of such as would try to make the Scales themselves, add the following Directions. 1. The whole Beam, together with its Tongue, must be cut out of one and the same Plate of Steel: For any foldered Bit may be easily separated, because this Beam must be worked with extraordinary

ordinary Delicacy. 2. The Axis, being a very fine Peg, must be fastened with Solder, in the Hole pierced in the Center of the Beam: Which is very easily obtained, if you cover over with a thin *Lamina* of Gold, the Middle of the Axis which is to go through the Center of the Beam: For *Steel* may be soldered with *Iron* by means of *Gold*, in a gentle Fire; otherwise you must use a more violent Fire, whereby the Axis is easily destroyed. 3. To temper the Beam you must first, when it is white hot, extinguish it in cold Water, and then rub it all over with *Oil*, and keep it upon the Fire, till the *Oil* is burnt and consumed: And if you do this two or three Times over in the same Manner, you will at last give it a spring-Temper. However, you must do this, before the Beam is quite worked. Next to this, you must make again the Extremities of your Beam white hot, at a Candle; that, being made a little softer by this Means, they may be bended without Difficulty; and in Case of Necessity be lengthened or shortened, to be corrected.

271. If the Fault of the Balance consists in the Inequality of the Arms, as to their Length or Weight, and if it is good in any other Respect, and you have not Time to mend the Fault previously: You may use it, mean while, in the following Manner. Put the Body to be weighed in one of the Scales, and put in the other, Weights to an Equipoise: Then mark exactly the Sum of the Weights: And then interchange the Powers, without however changing the small Dishes: Mark likewise the Sum of the Weights, to be added for the procuring of an Equipoise, which will certainly be different from the foregoing Weights: Then multiply the Quantities of both these Weights by each other, after having first reduced them into very minute Parts, as for instance into Drachms: And finally, extract the square Root of the Produce of this Multiplication, which will mark the true Weights of the Body in question.

272. As

272. As the Assayers' Scales hitherto (§ 263--271.) described, and made as delicate and nice as is requisite, cannot without Detriment bear above two docimastick Centners, or Drachms; you must have another somewhat stronger Balance, that may be loaded with a few common Ounces, which serves to weigh the several *Fluxes*, the *Additions*, *Lead* and *Ores*, especially those of *Copper*, *Iron*, *Lead*, *Tin*, &c. Let this likewise be made exact, and suspended on a Support.

273. As many kinds of *Weights* are used by Artificers that work in Metals, to weigh them, so many must the Assayer have at hand, because he is much more taken up with his Art than any, and must not be obliged to consume his Time in arithmetical Calculations, for the Reduction of his Weights. But the Weights which are properly called Assayer's Weights, are a thousand times smaller than common ones; because, the Portions of Metals or of Ores examined in docimastical Operations are extremely small.

274. The Metallurgists, who extract Metals out of their Ores, use a Weight divided into a hundred equal Parts (they call them *Pounds*) the whole of which they call a *Centner*, or an hundred Weight. The Pound is divided into thirty two Parts called *half-Ounces*, (in German *Loth*); the half Ounce again, is divided into two Quarters, and the Quarter into as many Drachms, called in German *Quintlein*. There is hardly any further Subdivision of the Weights, used in large Works. However it is proper, that the Assayer should also have a *Drachm* divided into two equal Parts; because he must sometimes have regard to such minute Quantities. Finally, to be able to weigh all the Parts of a Centner just mentioned, you must have at hand as many different Weights, as are requisite, to compose from them each of the Parts of the Centner.

You must therefore have at hand:

1	A Centner weighing	—	100	} Pounds.
2	A Weight	— — —	64	
3	— — — — —	— — —	32	
4	— — — — —	— — —	16	
5	— — — — —	— — —	8	
6	— — — — —	— — —	4	
7	— — — — —	— — —	2	
8	— — — — —	— — —	1	

9	A Weight	$\frac{1}{2}$ Pound	f. 16	} Loths.
10	— — —	$\frac{1}{4}$ — — —	f. 8	
11	— — —	$\frac{1}{8}$ — — —	f. 4	
12	— — —	$\frac{1}{16}$ — — —	f. 2	
13	— — —	$\frac{1}{32}$ — — —	f. 1	

14	A Weight	$\frac{1}{2}$ Loth.	f. 2	} Drachms.
15	— — —	$\frac{1}{4}$ — — —	f. 1	
16	— — —	$\frac{1}{8}$ — — —	f. $\frac{1}{2}$	

275. The Divisions and Denominations of Weights hitherto given (§ 274.) are equally used by Assayers and Metallurgists; with this Difference however, that the *Centner* of Metallurgists contains one hundred common Pounds; whereas that of the Assayers contains only one real Drachm, to which the other Parts are afterwards proportioned.

276. As then the docimastical Weights are divided to such a Degree of Minuteness (§ 275), and so vastly different from the common ones; the Assayer must be able to make them with his own Skill, which we must now teach him how to do.

277. These Weights (§ 274.) are made of square Silver * Plates, of such a Size, as that the Mark of each different Weight, may be put upon them. Let

* If you do not care to bestow *Silver* on your Weights, thin Pieces of fine Solder will do as well.

us first take for a Basis one Weight, being about two thirds of a common Drachm, and let it be marked (64. *lb.*) Then have at hand granulated Lead, washed clean, well dried, and sifted very fine: Put as much of it in one of the small Dishes of the Assay-balance, as shall be necessary to equipoise the Weight (64. *lb.*) just mentioned, which is in the opposite small Dish. This done, take out of the Dish the Silver-Weight, and put in the Room of it half of the granulated Lead; so that a perfect *Equilibrium* may be obtained. Then pour the granulated Lead out of each small Dish, and instead of it put another Silver-Weight already made, like the foregoing, being a little heavier than half of it, and mark it (32. *lb.*) taking great Care, that not the minutest Part of the granulated Lead remain in the small Dish. If this second silver-Weight exceeds by much that of the granulated Lead being still in the other small Dish; you must take a little from it, with a delicate thin File: And if it exceeds it but little, use a small Whetstone, that will rub off but a little at a time, comparing your Weights pretty often, till you render this perfectly equal to the granulated Lead. Then interchange the small Dishes; that, if the Balance has possibly been vitiated, or any Error committed, it may necessarily appear. Go on in the same Manner, till you have made all the small Weights. But if you finally will have one entire hundred; add to the Weight 64. *lb.* one of 32, and another of 4. *lib*; and taking them together, make one larger *Silver* Plate of equal Weight with them, and mark it (100 *lb.*) Thus you will have a sufficient Number of Weights, out of which you will be able to compose all the Parts of the Hundred, by intermixing them.

278. You will often want a centner-Weight larger than the common Drachm, which may likewise be easily made of one Size, according to the Rules (§ 277.) above prescribed. However, it is proper that this Weight be proportioned to the smaller Centner, and

to its Parts; that for Instance it should be exactly the Double or Quadruple: By which Means the lesser Centner, together with its Parts, serve to determine also the Parts of the larger.

279. You will find out, whether the Weights are made exact, or have contracted Faults in the using, by comparing the Centner, or its larger Parts, with the lesser ones: For Instance, the whole Centner, with 64, 32, and 4 *lib.* the 64 *lib.* with 32 *lib.* and with two 16 *lib.* and so on. It is then proper to have two Weights of each peculiar Part of the hundred *lb.* Which is the more easily done, because in the making of the Weights, it is a most tedious Work to determine the right Quantity of the granulated Lead: Which being once done, it is an easy Matter to prepare two Silver-Plates equipoising the same Quantity of granulated Lead.

280. Put these Weights (§ 277, 278.) into a small Case or Box, that may be shut, and in which there are for each of them proper and neat small Partitions contrived, and lined with Leather or Cloth: That every one may immediately be found, and that many of them being put together in one and the same Partition, may not rub against and wear out each other, whereby they are very easily spoiled.

Scholion. *In the making of the Weights (§ 277.) some use to determine the smallest of them first, and then to arrive at the hundred lb. by multiplying; but then an insensible Error committed in the smallest Weight, becomes very considerable, as it is multiplied over and over, and you lose all your Labour. On the contrary, if you first determine the largest Weight, as some use to do; you have much ado afterwards to find out the smallest: For it is hardly possible to proceed with dividing into two, from 100 to 25, and more. This is the Reason why I begin from 64 lb. not making any Weights of 50, or 25 lb; because they may easily be obtained by the Combination of the others.*

281. The common hundred Weights varies according to the different Places: For it often contains more
than

than 100 *lb.* and most commonly it is carried to one hundred and ten. Therefore, when the Docimaistical Operations must be adapted to the Proportion of the Common Centner, you must add as many Pounds to the docimaistical 100 *lb.* as the common hundred Weight contains above one hundred Pounds.

282. The Workmen, to determine the Weight of *Silver* and *Gold*, use one half Pound, or a Weight of eight Ounces, which they call *Mark*, and divide it variously. To assay *Silver*-Coins, and *Copper* mixt with *Silver*, they divide the *Mark* into 16 half Ounces, (*Loth*). The half Ounce into four Drachms, (*Quintlein*) ; the Drachm into four Penny-weights (*dwt*), (*Pfennige*) ; and finally, the *dwt* into two $\frac{1}{2}$ *dwt*, (*Heller*) : this Weight is called *Nummularium*, *Pfennige Gewichte*, or Penny-weight.

283. It will not be necessary to have at hand the Weight just described (§ 282.) if you can substitute to it a Weight of sixteen Pounds of the docimaistical Centner (§ 274, 277.) for if this represents the entire *Mark* ; in that Case each Pound of it will be equal to half an Ounce of the Weight (§ 282.) ; eight half Ounces will be equal to one Drachm, two half Oz. equal to one *dwt*, and at last one half Ounce be equal to one $\frac{1}{2}$ *dwt*.

284. To temper *Silver* with *Copper*, the *Mark* is likewise divided into sixteen half Ounces, as (§ 283.) But the half Ounce is then divided into eighteen Parts, which they call *Grana* or Grains, but *Georg. Agricola*, in better *Latin*, calls them *Quaternas Siliquas*, and finally the Grain is divided into four Quarters. Therefore in this Case, the greatest Weight is the *Mark*, or half Pound, which weighs about half a Drachm of the common Weight : The second is half Ounces, the third is four ; the fourth two ; the fifth one ; the sixth one half of this, or nine Grains ; the seventh six Grains, the eighth three, the ninth two, and the tenth but one Grain ; the eleventh one half Grain, and finally the twelfth one quarter part of a Grain. There is no peculiar Observation to be added concerning

cerning the making of Weights of this kind, besides what was said before (§ 277, and following). For this is as commonly used as the foregoing (§ 282), especially in *Germany*.

285. In *Holland*, instead of the Weights described (282, 284). Assayers use the *Marca Nummularia*, or Mark of the Mint, which is divided into twelve Penny-weights, and each Penny-weight is subdivided into twenty-four Grains. Now this Mark of the Mint weighs a common half Dram, which is the first Weight; the second is six Penny-weights, the third three, the fourth two, the fifth but one Penny-weight, the sixth twelve Grains, the seventh six, the eighth three, the ninth two, and the tenth one Grain. They make no further Subdivision.

286. To temper *Gold* with *Silver* and *Copper*, they use the Caract-weight (*Carath-Gewicht*), the Mark of which is divided into four and twenty Caracts (*Carath*), and the Caract into twelve Grains. Therefore the first Weight is here, as in the foregoing, a Mark of four and twenty Caracts; the second is twelve Caracts, the third six Caracts; the fourth three; the fifth two; and the sixth one; the seventh one half Caract or six Grains; the eighth three Grains, the ninth two, and the tenth one Grain.

Scholion I. *Besides the Varieties of Weights, hitherto (§ 273, and following) mentioned, there are still a great many others different from them: But it is not our Business here, to treat of them all in a more particular Manner. See G. Agricola. Lib. VII. De re Metallica.*

Scholion II. *As the Dutch Mint-Mark (§ 285), the German Grain-Mark (§ 284) and the Caract-Mark (§ 286), are each divided into two hundred and eighty eight Grains; it is self evident, that you need have but one of these three; for twelve Grains of either of these Weights make one Penny-weight, eighteen make one half Ounce, and four and twenty make one Caract.*

287. Any Metal whatsoever, when pure, must have its specifick Colour, that distinguishes it from the Rest. But, Metals being the most opaque of all known Bodies,

dies, the specifick Colour of every one appears very distinctly, when you rub it against a very black hard Stone. If then the Colours of two or more Metals to be assayed, are expressed by large lively Spots made near each other in the same Plane, after having rubbed them against the Surface of such a Stone, you will by that Means easily discern their Difference, or their Likeness.

288. The Stone adapted for this Use (§ 287.) is called the *Touch-Stone*; which must have the following Properties. 1. It must be of the deepest Black, lest the Tincture of the Metal should be hindered, by spurious Rays of Light shining between them. 2. It must be capable of being pretty well polished: For when too rough, the Colours of the Metals rubbed against it, cannot be neatly perceived: And if it is too smooth, the Metals are but faintly and slowly scraped by it, especially *Gold*. 3. It must be neither too hard, nor too soft: For *Tripoly*, *Coal-Dust*, and *Tin-ashes* rub off the small metalline Crusts: So that, in a short Time, this Stone, though ever so hard, acquires too great a Smoothness: And when it is too soft, it is easily ground into a fine Dust, and contracts Furrows. Therefore, black rough Marble, or black soft River-Pebbles, are excellent for that Use. They must be made into a quadrangular Prism, about one Inch thick, and two or three Inches long; which is the most convenient Figure for that Purpose.

289. The Metals which are tried in the Manner mentioned, are *Gold*, *Silver*, *Copper*, when pure, or mixt among themselves by Fusion, in many different Proportions. But in order the better to find out the Purity and various Mixtures of these Metals, whenever they are to be examined; the Masses to be tried are compared with small pure Masses of the same Metals, or of Metals mixt in a known Proportion, and designedly prepared for that Use, which are called Touch-neededles. Now the aforesaid Metals, both those pure and those mixt in different Proportions, are made into

Lamina's

Lamina's one Line broad, one fourth Part of a Line thick, and one Inch and a half long, upon each of which you engrave a Mark, indicating their Purity, or the several Mixtures of the Metals which they are made of.

290. Let us now shew the Manner of making these Touch-needles (§ 289); and first of all the Silver ones. These must be tempered only with *Copper*: But the Proportion is determined by the Mark (§ 284.) divided into half-Ounces and Grains. Therefore, you must use for that Purpose one Mark of such a Weight, as that it may constitute a sufficient Mass of Metal for the making of one Needle: Let it then weigh, for Instance, one whole Dram. Then weigh such a Mark of the purest Silver, wrap it in a small Paper, upon which you will write sixteen half Ounces; which will signify, that the whole Mark of this Metal is the purest Silver. Make the first Needle with this Mass. Next, weigh fifteen half Ounces of pure Silver, and one half Ounce of pure Copper; wrap them both together in a Paper, and mark upon it fifteen Ounces, which will signify, that there are in that small Mass fifteen Parts of pure Silver, and one of pure Copper. Make of this the second Needle. Then add two half Ounces of Copper to fourteen half Ounces of pure Silver; and mark it fourteen half Ounces. Make a third Needle of this. Go on thus, and proportion the small Masses of Silver and Copper for the making of the other Needles, and put Inscriptions upon every one in the following Manner.

	4 th	13	3	
	5 th	12	4	
	6 th	11	5	
	7 th	10	6	
	8 th	9	7	
	9 th	8	8	
For Needle the	10 th	7 half oz. of Silver	9	half oz.
	11 th	6	10	of Copper.
	12 th	5	11	
	13 th	4	12	
	14 th	3	13	
	15 th	2	14	
	16 th	1	15	

Let then each of these Portions of Metal, as they are wrapt in a particular Paper, be put separately into a new Crucible, never used for any Operation; and, adding a little Borax, melt them in a very quick Fire, which must be well kindled before with Bellows; or, what's still better, throw them suddenly into a white hot Crucible, and, so soon as they melt, stir them with a dry wooden-Peg, burnt at the End, and pour them immediately into an Ingot. This Fusion may as well, and almost more conveniently, be made with a cementatory Tube (§ 258). Next to this, wrap each small Mass, grown cold, into its Paper again, to avoid Confusion, and again try them singly in the Balance. If they still weigh a whole Mark, they are good: But if there is any considerable Deficiency in the Weight; it is a Sign that your Fire, having been too weak, or of too long a Duration, has consumed as much Copper, as is wanting in the Weight: Therefore, instead of this small deficient Mass, another must be made in the same Proportion. Then with a Hammer, make a Needle (§ 289.) of each of these small Masses, making them a little red hot, when the Metal begins to grow stiff under the Hammer. This done, engrave upon every one of these Needles the Number of half Ounces of Silver which they contain; that is, upon the first, 16; upon the second 15; and so on. Then pierce them at one End, and running a Silver-

Silver-Wire through their Eyes, collect them in Order, according to their different Numbers. These are called Silver Touch-Needles, but they call the several Temperines of Silver with Copper, *Allays*.

291. Some determine the Proportions of their Needles by half Loths: Others use still smaller Divisions, the Compositions and Numbers of which may be easily known from (§ 290). But you can hardly distinguish any thing of Silver-Allay, by your Needles, when you divide beyond half Loths.

292. You may also add to these Silver-Needles (§ 290.) one made of pure Copper: For with these you may at the same Time find out the Purity of the Copper, or its various Mixtures of Silver.

293: In *Holland* they use the Mint-Mark (§ 285) divided into Grains, for the making of Needles. But then, the first Needle, made of pure Silver, is said to be twelve Penny-weights. The second is made of eleven Penny-weights and eighteen Grains, by the Addition of six Grains of Copper. The third is made of eleven Penny-weights and twelve Grains, with twelve Grains of Copper; and so on: the Proportion of the Silver decreasing always six Grains at a Time, that is, one quarter Part of a Penny-weight, and that of the Copper being always increased in the same Proportion; till at last the Weight of the Silver is diminished to one Penny-weight, and the Quantity of the Copper augmented to eleven Penny-weights: Which Proportion constitutes the last Needle, beyond which you are not to proceed.

294. However, it is needless to go through the whole Series of the Needles, by so small Progressions, to the very last. It is enough for us, to have indicated quarter Parts of a Penny-weight to one Needle of nine Penny-weights (§ 285), and the half-Ounces to one Needle of ten Semi-ounces (§ 284); for afterwards, you cannot accurately distinguish Proportions so very delicate, in the following Needles.

295. *Gold*, when you are to make Gold-Needles, must be mixt either with Silver alone, or with Silver

and Copper variously intermixed. But this Mixture is called *allaying*, or *carraeting*, and is determined with a Mark divided into Caracts, or Weights of two sixth Parts of an Ounce (§ 286). There is nothing to be observed about the making of these Needles, besides what has been already said of the Silver-Needles (§ 290), except that the Proportions of the Weights are determined in another Manner. These Needles are made according to the following Division and Order. They all weigh eight Ounces, or one Mark.

The first is entirely made of pure Gold.

2 ^d	23 Car. 6 Gr.	} Pure Gold. }	6 Gr.	} Pure Silver.
3 ^d	23 Car.		1 Car.	
4 th	22 Car. 6 Gr.		1 Car. 6 Gr.	
5 th	22 Car.		2 Gr.	
6 th	21 Car. 6 Gr.		2 Car. 6 Gr.	
7 th	21 Car.		3 Car.	
8 th	20 Car. 6 Gr.		3 Car. 6 Gr.	
9 th	20 Car.		4 Car.	
10 th	19 Car.		5 Car.	
11 th	18 Car.		6 Car.	

The Decrease goes on thus by whole Caracts, till the Weight of the Gold is arrived at one Caract, and that of the Silver at twenty three: for after the ninth Needle, you cannot make so exact a Distinction of the half Caracts. Now, this Mixture of Gold with Silver is called *the white Alloy*.

296. But when Copper together with Silver enters into the Mixture of the Gold, it then is called a *mixt Alloy*: This is composed in the same Manner as the foregoing (§ 295), except only that those Portions, which in the first Case were pure Silver, here consist of Copper and Silver. Therefore, you have here again a double Series: For you mix either two Parts of Silver and one of Copper, or two Parts of Copper and one of Silver; for Instance:

The

The first is of pure Gold.

2 ^d	Of pure Gold.	23 Car. 6 Gr.	Of pure Silver.	4 Gr.	Of pure Copper.	2 Gr.
3 ^d		23 Car.		8 Gr.		4
4 th		22 Car. 6 Gr.		1 Car.		6
5 th		22 Car.		1 Car. 4 Gr.		8
6 th		21 Car. 6 Gr.		1 Car. 8 Gr.		10
7 th		21 Car.		2 Car.		1 Car.
8 th		20 Car. 6 Gr.		2 Car. 4 Gr.		1 Car. 2 Gr.

And so on, as in the foregoing.

297. If in the Table just mentioned (§ 296), you take pure Copper, instead of pure Silver, and Silver instead of Copper; this gives you a third Series of Golden-Needles. And you will have a fourth, by mixing with Gold equal Quantities of Silver and Copper, in the same Proportions mentioned (§ 296).

298. The Allays of Gold hitherto explained (§ 295, and foll.) are very much in use. However, it is plain, that Workmen may easily employ an infinite Number of other Variations; which, being compared with those above-mentioned, may be distinguished in a thousand different Ways, by an experienced Man: So that it is neither possible, nor necessary, to imitate them all.

299. But lest the Golden-Needles (§ 295 and foll.) should be too expensive; they may be made much shorter than the Silver ones (§ 289, 290), and be soldered to Plates of Copper; that they may be sufficiently long for Use.

300. Now, if you light upon a Metal (§ 289), which you think wants to be tried upon the *Touch-stone*; wipe it first with a clean Towel, or Leather; that you may see the true Colour of it: for from this you may, in a Manner, judge before-hand, what Metal it is, and how much, or with what other Metal it is mixt. Then chuse a convenient and not over large Part of the Surface of your Metal, and at several Times rub it strongly against the *Touch-stone*; that, in case a deceitful Crust should have been laid upon

the Metal, it may be scraped off by a strong Friction: which however may be done still quicker with a Grindstone, or a delicate File, if you have them at hand. Then wipe a flat and very clean Place (§ 288.) of the Touch-stone, and rub against it the same Part just mentioned of the Surface of your Metal over and over; till the flat Part of the Stone be equally and neatly covered with a metallick Crust, one Inch long, and one Line and a half broad. This done, chuse the Needle, that you shall judge answers nearest to the Metal rubbed; which Choice is learned by frequent Practice. Then wipe the lowest Extremity of this Needle very well, and rub it against the Touch-stone, as you did the Metal, by the Side of the first Plain, and in a Direction parallel to it. If you can find no Difference between both Plains; you may pronounce with Probability, that the Metal to be tried is of the same Temperature, as the Needle you have compared with it: which Temperature is shewed by the Number ingraved (§ 290. *and foll.*) upon it. But if you find a Difference between the Colours; chuse another Needle, in case you shall find the Metal of a deeper or a lighter Colour than the first Needle: Thus you will at last find a proper Needle, answering to the Temperature of the Metal; or at least you will be able to judge, that the Allay of Metal is extraordinary, and cannot be determined by your Needles.

301. Mean while, as not only the Surface, but also the whole Mass of the Metal may be dyed with a spurious Colour, which may be produced many different Ways; you may easily see, from the Colour of any Metal compared with your Needles, that you can pass no certain Judgment upon it, unless you know that the Gold and Silver are mixt, and what the Metals are wherewith they are so mixt: whether, for Instance, it is Gold and Silver, Silver and Copper, or all these three perfectly pure, without any Mixture of another Metal. For, in this Case, the Comparison of the Colours with those of your Needles, may inform

form you of their Temperature. Nor can, however, this Determination be made exact to a few Grains, by this Method.

302. But if the Colour of the Metal has been altered (§ 57, 71, 83, 88.) by Tin, Arsenick, Zink, &c. the Workman may be deceived by the Colour, so as to take for pure Gold or Silver, what is not such by the greatest Part. You find out the Deceit with *Aqua Fortis*, when the metallick Mass is of the Colour of Gold; and with *Aqua Regis*, when it is like Silver: for the first of these Liquors dissolves all Metals, *Gold* excepted; and the other likewise all Metals, but *Silver*. In such Case then, you pour upon the metallick Streak, or thin Crust rubbed upon the Touch-stone, one single small Drop of either of these dissolving Liquors, and extend it gently with a Feather; if it is neither Gold nor Silver: the whole Streak will be consumed: but, if there is any Gold or Silver in it, this remains undissolved, and shews another Colour; because the other Parts have been separated from it by the Solution. Take care however, when you make use of these *Menstrua*, that there is no oily Mixture with them; because this would render them of no Effect.

303. Besides this, you are to observe the following Particulars concerning the Use of the Touch-stone.
1. Gold and Silver, pure and separate, or both mixt together, without any other Matter added to them, when made white hot in the Fire, not only preserve their Colour, but also entirely recover all their Splendor there, when tarnished, not losing the least Part of their Weight (§ 6, 7): on account of which Quality the *Caratura alba*, or white Allay, is distinguished from all the others. But if you have not the Liberty to try the whole Mass in the Fire; you may make only a small Part of it white hot, with a blow-Pipe (§ 258). 2. If you find a Needle, whose Colour agrees with that of the Metal to be tried; both the Streaks imprinted upon the Touch-stone must undergo Changes altogether the same, when *Aqua Fortis*,

Fortis, or *Aqua Regis* is poured upon them ; that you may thus be certain, that there is no Fraud at Bottom : otherwise, you are not to doubt, upon any Account, your being deceived by a false Colour. 3. All Gold rendered brittle, when compared with the Needle upon the Touch-stone, appears less pure, than it is indeed found to be, by an accurate docimastical Examination : and, on the contrary, all Silver rendered brittle has the Whiteness of pure Silver in a higher Degree. Nor is it difficult to find out the Reason of this Difference : for the Bodies which make *Silver* or *Gold* brittle, are only a few Metals and Semi-metals, all of a very bright white Colour : such as *Tin*, *Lead*, *Iron*, *Regulus of Antimony*, *Bismuth*, *Zink*, and *Arsenick*. Now these dilute the yellow Colour of *Copper* and *Gold*, or change it into white : so that the Colour of the Copper mixt with Silver is then hidden ; whereas Gold, on account of these Mixtures, appears to have a great Deal of Silver in it. 4. In a white Allay *Aqua Fortis* does not discover (§ 302.) the Presence of *Silver*, from twenty three to seven Carats (§ 295), because *Aqua Fortis* does not separate *Silver* from *Gold*, unless the Mass contains three times more *Silver* than Gold. 5. Metallick Streaks or Crusts, which have been imprinted a while upon the Touch-stone, cannot be compared with fresh ones : for their remaining long upon it, commonly occasions an Alteration in the Colour. 6. *Silver*, when tempered with *Brass*, appears whiter, than it would, if mixt with a like Quantity of Copper : but as it may then be rendered sufficiently ductil by a proper Operation ; you will hardly be able to find out the Fraud with the Touch-stone, unless you make a second Time the Comparison with a Needle of the same Colour, having previously poured *Aqua Regis* (§ 302.) upon the metallick Crust, laid by rubbing on the Touch-stone. Nor are the Touch-Needles tempered with Brass of any great Use here ; because this artificial Metal is sometimes more, sometimes less yellow. 7. If the Metal, applied upon the Touch-stone, by rubbing,

does

does not appear neatly enough, lick it over with Spittle not frothy, and then the Colours will be more lively reflected.

304. Besides the Utenfils hitherto described (§ 168, 301) you must have a convenient Place for the performing of the docimaftical Operations. You must have a Chimney, large enough to place the Furnaces, and capable of quite confining the Fumes; which, tho' not all mortal, are nevertheless always hurtful, in almost all Operations when they can come out freely. But as these acid Fumes corrode the Metals themselves, it is not proper to keep in the Laboratory such metallick Utenfils, as must be preserved very clean; for instance the Scales, with their Weights, the Touch-Needles, &c. which must be kept in a cleaner Place: nor must you keep there many different *Menstrua*, except they are in Vessels perfectly closed: for some of them, by sending forth their Vapours, change the others, and are mutually altered by them; so that you can no longer make any exact Experiment with the same. Moreover, as you must frequently observe very minute Bodies, and their several Changes in and out of the Fire; the Laboratory, which in the first Case must be darkened, in this must be rendered very bright: which may be easily obtained, by hanging up thick or black Curtains against the Windows.

CH A P. IV.

Of compound Minerals.

Of ORES.

305. **H**AVING in our first Chapter given an Account of the simpler Minerals, and in the Second that of their principal Actions upon each other, as far as they can be so disposed by no great Art;

Art; we may now understand and explain the Nature of those Bodies, which, being composed of the foregoing, are found natural in the fossile Kingdom. The Knowledge of these, though we could hitherto give it only historically, has nevertheless a vast Utility in the exercising the practical Part of Assaying; for he that is well imbued with it before-hand, may very well dispense with many vague Experiments, which he is obliged to go through, when altogether a Stranger to the several natural compound Bodies.

306. But the useless Descriptions given by many Authors and derived most of them from accidental Properties; the Difficulty of obtaining the best Specimens from different Countries; the Variety with which Minerals are mixt together in their minutest Particles (§ 32); in short, the Difference of the Works of Nature, and of those of Art, though they are made of the same Principles united in equal Proportions; render this Part of natural History equally difficult and defective. Add to these the Variety of outward Figures wherein Nature seems to delight still more in the mineral, than in the vegetative and the animal Kingdoms.

307. Nor is the specifick Gravity of any great Help, in the distinguishing of compound Minerals. For, 1. when more than two Bodies of different specifick Gravities are mixt together, you can detect nothing by an hydrostatical Calculation; because a compound Mass of the same specifick Gravity may be produced by many simple Bodies, very different from each other, and mixt in a thousand different Proportions: Now the same is in reality found in the mineral Kingdom, as is shewn by docimastical Operations. 2. The accidental Matters inherent to Minerals, and the very Air imprisoned in the small Cavities and Clefs of several Ores, hinder an exact Ponderation, and now and then render it very difficult. 3. The simple Stones, which, being joined with almost all compound Minerals, are not only of infinite Variety, as to their specifick Weight, but some

are almost as ponderous as Metals themselves: such are a great many Species of Spaad.

308. However, I would not have the specifick Gravity, nor the Figure be altogether overlooked, but rather made use of with the other Characteristicks; though no constant and accurate Judgment can always be drawn from these alone.

309. But our Design being to lay down the Principles of the Art of Assaying; it will be necessary only, to mention the Characteristicks and distinguishing Marks of compound Minerals, as they are the most frequent Objects of the said Art (§ 2), and to shew their constituent Parts, as far as they make themselves known, together with the Disposition of the whole Body with several *Menstrua*. It is likewise evident, that we cannot here mention all Ores without Exception, but that we must only chuse those that are less compound, or those at least which are more frequently met with.

310. We shall refer every compound Mineral to the Class of that Simple, of which it contains the greatest Part in itself; except however *Stones*, and simple *Earths*: for if the Classes of these were to be determined from their predominant Parts; the Number of the Ores to be referred to that Class would be by much the greatest.

Scholion. *For Instance, let us suppose, that there are in a Lump, six Parts of Copper, and one of Sulphur, a very small Quantity of Arsenick, and twenty Parts of Quartz or Flint-stone; we shall class this compound Body with the Copper-kind, and so on.*

311. But we shall call a Mineral *proper* to that Simple, which makes the greatest Part of it (§ 310), and *improper* to those which it contains in less Quantity: However, they are contained in it in such Manner, that they indeed enter into the Mixture of it, and must always accompany it wherever such Mineral is found. Finally, we shall call it *accidental* to those Simples, which enter not into the Mixture of it, being only adherent to the Out-side: Wherefore, they may

may be or not be found with the Mineral now mentioned, and yet this Mineral remain still the same.

Scholion. *Let us clear this Matter by the foregoing Example* (Schol. § 310). *The Mineral supposed there, containing Copper in the greatest Part, is called proper to Copper. But so long as Sulphur and Arsenick are mixt together with the Copper, and render it of a particular Species, this Mineral, on account of the small Quantity of its sulphureous and arsenical Parts, is said to be improper to them. Finally, the Stones or other Bodies, placed about or among that Mineral, are called accidental to it, as they are no constituent Parts thereof, and it might subsist without them.*

Of Sulphur and sulphureous Minerals.

312. *Mineral Sulphur, or common Brimstone, when free of all foreign Mixtures, is of a solid, friable Consistence; yellow, made up of large Masses, and more or less half-transparent; it burns, makes a bluish Flame, with a suffocating acid Vapour (§ 22), and thus is entirely consumed: Being put upon a gentle Fire, and in close Vessels, it melts without taking Fire; and, when melted, changes its Colour into a bright Red: it no sooner grows cold again, but it resumes its Solidity and yellow Colour. It is composed of the purest inflammable Principle (§ 24), and of a much greater Quantity of Acid of Vitriol (§ 22): on which Account it sinks in Water, being much heavier than pure Oil. The Chemical Analysis, and the Production by Art of true Sulphur, out of the two Principles just mentioned, confirm what has been said of it.*

313. *In this State (§ 312.) native Sulphur is digged out of the Earth; though not so very frequently: it is likewise brought in such a State by Waters, which on this Account are called particularly medicinal, and it applies itself to the Walls of the Springs.*

314. *It is frequently found mixt with simple Earths and Stones; varying its Dye, and being sometimes*
white,

white, sometimes grey, yellow, or of other Colours, belonging to the Bodies mixt with it.

315. Whenever *Sulphur* is tinctured with a dark, or bright Orange or red Colour, this always betrays *Arsenick* in it: Wherefore, Sulphurs thus coloured are not true, nor very valuable.

316. The most frequent and almost the *proper* Mineral of *Sulphur* is the *Pyrites flavus*, or yellow *Pyrites*. This, when free of all heterogeneous Matters at the outside, and bright, has all the Appearance of polished Brass, and is more various as to its Form, than any other Mineral: however it is most commonly found of a globulous Form, then of a cubical hexagonal, both regular and irregular Figure. It is solid; unless it be rendered soft by a Mixture of soft Stones and Earths: when struck with a Steel, it gives Sparks like a Flint: when brought near a gentle Fire, it soon bursts, with a crackling Noise; and emits small Flames almost sulphureous: it changes its yellow Colour into a dark red, and its neat Surface into a dusty one. It is very rich in Sulphur, and contains one quarter, sometimes almost one third Part of it. Moreover, there is always a Quantity of Iron lurking in it; its sulphureous Part is sometimes greater, sometimes less: and *Henckel* has found that it also contains a kind of *Earth* not metallick, and in a various Proportion as to the other Parts: which makes us easily guess, that the specifick Weight of the *Pyrites* must be very various. The Author just mentioned has, in his Treatise on *Pyrites* *, given us a very ample History of this Mineral, together with a very accurate Analysis of it.

317. There are very few Minerals altogether destitute of Sulphur: but as the extracting of it would never pay the Charges, and they besides contain Metals and Semi-Metals in a greater Quantity; for this

* *Pyritologia, oder Kieſs-Hiſtorie, &c. gefertigt von D. Johann Friedrich Henckel. Leipzig. 1725, in 8^{vo}.*

Reason, we shall mention them in those Places, to which they properly belong (§ 310, 311).

318. We may also refer to this Class all the inflammable Minerals, that differ from Sulphur strictly so called (§ 312.) by the Quantity and Quality of their Acids. Such are *Naphtha* and *Petroleum*, that distil from *Stones*, or swim upon the Waters of Fountains. They differ hardly among themselves, and are sometimes very limpid and thin, sometimes yellow and thick. But when these Matters are grown very thick, and have assumed a dark Colour, they are called *Bitumen*; *Pix Judaica*; *Asphaltum*: and when at last grown harder, they turn into a Stone called *Gagates* or *Feat* *. There occur besides, other the like Names of sulphureous Matters, which, however, seem hardly to signify other Concretes, different from those just mentioned.

319. The very same (§ 318.) oily Mineral, when it hardens, and adheres to a stony Matrix, becomes that kind of fossil Coal, called *Stone-coal*, *Quarry-coal* or *Sea-coal* †: which is a black concrete Body, easy to be cleft, consisting of Lamina's, and bright: much heavier than the foregoing (§ 318); not quite so quickly inflammable, but preserving its Flame, when once kindled, longer and more violently than any other Fuel; leaving, after it is burnt, not so much Ashes, as a Mass half scorificated, blackish, spongy, and often containing a yellow Pyrites (§ 316.) in it.

320. *Amber*, called in Latin *Electrum*, *Succinum*, of a blackish, dark yellow Colour; half transparent, frequently very transparent; light; sinking however in Water; very hard, so as not to soften at the Heat of boiling Water; melting nevertheless in a strong

* Of which Kind is the greatest Plenty in some Parts of *England* and *Scotland*, known by the Name of *Kennel coal*, *Staffordshire-coal*, and *Scotch coal*: out of the first several curious Vessels are turned and carved, as of *Amber*, of which *Feat* is a Species, and may be called *black Amber*.

† Which is the common Fuel in *London* and the maritime Parts of *England*.

Fire, foaming, and yielding a solid acid Salt, belongs also to this Class. It dissolves, by a Chemical Distillation, into Oils, which are thin at first, and by degrees become thicker, and into an acid solid Salt: These Oils have so much Affinity to *Naphtha* and *Petroleum* (§ 318), that we see, if not always, at least most frequently, Apothecaries and Druggists use them in room of these natural Fossils. The *Caput Mortuum* remaining after the Distillation, is not unlike *Bitumen* (§ 318), and is even sold under that Name.

Of Arsenick, and arsenical Minerals.

321. The Crystalline, pure Arsenick described (§ 17) *, is got out of the Mines under the same Form, and looks white and dusty: however it is very seldom found natively such.

322. The same (§ 321.) is digged out under the Form of a black or ash-coloured Stone, which being broken when fresh taken out, is within of a bright bluish White, which however, being exposed to the open Air, becomes dark and blackish in a few Days.

323. Next to this the white Pyrites, which is heavy, bright, striking Fire against a Flint, and of a Figure altogether irregular, contains a very great Quantity of Arsenick, of Iron but little, more of Earth not metallick, and is most frequently found in Mines.

324. *Orpiment*, which is a Mineral of a Golden Colour, filled here and there with small Masses of the Colour of Cinnabar, easy to be cleft, made up of Flakes, soft with some Tenacity, bright when broken, contains a great Deal of Arsenick, less of mineral Sulphur (§ 312): wherefore, it burns dark in the Fire, giving a whitish blue Flame, with a most thick white

* *Arsenick* is vulgarly called in English *Rats bane*, and from its Colour is distinguished into the white and yellow *Rats bane*, being the Poison usually employed for destroying Rats.

Smoak. It melts as soon as it burns; when melted, if you pour it upon a clean Iron or marble-Table, growing cold, it turns into a solid Body, of a dark red Colour, brittle, bright, and half-transparent*; However, there remains upon it a Cream which is of a less fluid Nature, like imperfect *Scoriae*, which being burnt in a great Fire, separates into Earth. It is digged out in *Hungary*, and in the *East Indies*.

325. *Cobalt* belongs to the same Class. It is a ponderous Mineral, finely striated, or sometimes granulated, sometimes also smooth at the Outside, sometimes of a light greyish, almost semi-metallick Colour, and sometimes of a dark blackish Dye. It contains a great Deal of Arsenick, and a good Quantity of a certain fixt Earth, which being melted with Flints and fixt Alkali, turns into Glass, of the finest Blue, inclining howsoever to the violent Colour called *Smalt*†. Besides, *Cobalt* most commonly contains Bismuth (§ 15.) There are also many different Minerals called *Cobalt*, which nevertheless have Properties altogether different from those just mentioned.

326. However, the Mineral called Flower of *Cobalt*, which is finely striated, not very compact, and on this Account lighter than the foregoing (§ 325), and of a fine red purple Colour, belongs likewise to the *Cobalt* kind. For it is a very arsenical Mineral, so that it loses above one half of its Weight in the Fire; but you may afterwards melt a great Quantity of *Bismuth* out of what remains: and this besides gives

* And when it hath been thus melted, and of a Vermilion-Colour, it is called *red Arsenick* or *Sandarach*.

† The *Stone-blue*, or *flaky-Blue* for sprinkling upon Wood fresh painted over, and the *Powder-blue* used in washing Linnen are Preparations of this Mineral; and the Manufacturing of it brings in great Profits in some Parts of *Germany*; but if our English Mineralists were curious in their Researches, they might certainly find both *Cobalt* and *Bismuth-Ore* in *Cornwall*, and other Parts of *England*: there having been formerly sent to the Royal Society Specimens of these Ores, among Specimens of Tin and other Ores. See the Note (§ 407.)

Glass the azure Colour, as the other true Cobalts do. On which Account it is true *Cobalt*, though outwardly it seems to differ very much from the common Sort (§ 325). It has indeed *Cobalt* (§ 325), for its Basis, and seems to be produced by it, by a Germination as it were like that of Plumose Allum.

327. These (§ 325, 326.) are the principal Species of true Cobalt, which all agree in this Point, that they have a very great Quantity of Arsenick in them: wherefore they are here referred to the Class of arsenical Minerals, though they sometimes have that Difference from other arsenical Bodies, that, after the Sublimation of the Arsenick, they leave a *Caput Mortuum*, which tinges white Glass of an azure Colour. There are likewise many other Minerals, which they commonly call *Cobalt*. But as they are totally different from the true Cobalt, and even do not contain the least Sign of Arsenick; for this Reason, and to avoid Confusion, they deserve to be expelled out of the Class of *Cobalt*.

328. Nevertheless, there is a certain Mineral, that deserves to be referred to this Class: it is rich in Arsenick, somewhat like Cobalt (§ 325), of a grey reddish Colour, it looks like a Semi-metal; it contains also a little Copper, and a little Sulphur; the *Germans* call it *Kupfer Nickel*.

329. There are also a great many other Minerals, which, on account of the Arsenick contained in them, are likewise referred to this Class. But as there is in them a greater Quantity of Metal than of Arsenick; for this Reason, they shall hereafter be reckoned among other Classes, as being improper (§ 311.) to Arsenick. I shall only add, that Arsenick makes itself known in all Minerals, by its white Smoak, and by its foetid garlick-like Smell, when you put them upon burning Coals, or in a small Vessel made white hot in the Fire.

330. Finally you are to observe here, that Arsenick lies hidden in a great many simple Stones and Earths, especially those that shine and adhere

strongly to them; and that when agitated by a violent Fire, it renders them for the greatest Part volatile. The famous *Hankel* has observed, that it sometimes lies hidden in marly and clayey Earths. See his *Pyritolog.* p. 611.

Of ORES in general.

331. When Metals and Semi-metals are penetrated with Sulphur and Arsenick, they always lose, either that universal Character which is common to all Metals and Semi-metals, or that which is peculiar (§ 517.) to them alone. *Lead* and *Tin*, confounded with *Sulphur*, not only lose that Character which is common to all Metals, viz. their Malleability, but are also deprived of the Properties peculiar to them, that is, when in a certain Situation in the Fire: for then, they both require a much greater Fire to be melted, than they would, if they had been free from Sulphur, and lose besides their Colour. The purest granulated Silver, confounded with Sulphur, retains its Malleability, Fusibility, and the other Properties that are common to all Metals; but it loses those that are peculiar to itself: for its most white Colour changes into that of Lead; its hard Consistence turns into the Softness of the same Metal; and finally, when it is but a little heated in the Fire, it then, if pure before the Fusion, melts so soon as it grows red. But metallick Bodies are most commonly in that State naturally, except *Gold* alone.

332. Natural Concretes, of Metal or Semi-metal, mixt with Sulphur or Arsenick, or with both together, are called *Ores*. But when such Alliances are made by Art, we then say that the Metals or Semi-metals are reduced to the State of *Ores*.

333. As, therefore it has been found hitherto, that the Causes of this particular strange Form (§ 331.) given to metallick or semi-metallick Bodies, reside in the Sulphur and Arsenick incorporated with their Substances; it would seem to be an easy Matter, to imi-

rate (§ 332.) by Art natural Concretes of this Kind: and it indeed has succeeded very well with some. Thus for Instance, the Silver vitreous Ore, the Ores of Mercury, and of *Regulus* of Antimony, may, by Art, be rendered perfect and like the natural ones; if to Silver you join Sulphur, or *Regulus* of Antimony by Fusion, and to Mercury by Trituration and Sublimation. But the other Ores have not hitherto been so well imitated by Art: nay, this gives Birth to Products very different, though you use the same Ingredients, such as may be fetched out of natural Bodies, and even in the same Proportion. But the Reason of this Variety, seems to be in the Manner and Time, in which *Arsenick* and *Sulphur* are by Nature joined with Metals or Semi metals not yet thoroughly tried, and sometimes perhaps, when there is another Body, either not known at all, or not sufficiently known: such is the Earth containing no Metal in the true Pyrites and Cobalt (§ 316, 325), the Nature of which is not yet tried, with a sufficient Degree of Certainty.

334. *Ores* (§ 332.) are distinguished by Assayers, into fusible, refractory, and not fusible at all, according to their relative Dispositions, with regard to the Fire and the *Menstrua*. Those are called fusible, which, either by Means of a middling Fire only, or by adding a fit *Menstruum* to them, melt easily, and as far as is necessary to obtain the Fusion of a Metal or Semi-metal. The Refractory are those, which require a very strong and lasting Action of the Fire, to be melted in the requisite Manner. But when they cannot be melted in the most violent Fire alone, and require the additional Action of a *Menstruum*, to be put in Fusion, they are called not fusible. But it is plain enough, that there are still many different Degrees, in each of these Classes.

335. The Reason of the Disposition of *Ores* in the Fire, and with regard to the *Menstrua*, lies hidden either in the Nature itself, or, as they call it, in the Essence of the Ore, or in the Nature of some Body

accidentally residing in it. But this Body again, has this Property of itself, or at least is such relatively to this or that Ore to which it is adherent.

336. As we are here upon *Ores* in general, we shall only touch upon those Things, which, by their Presence, render almost all *Ores* refractory, or altogether unfusible. But we shall mention in our practical Part, when we treat of *Ores* in a more special Manner, the Things which produce this Effect, only with regard to some particular kind of Ore. All *Ores* lie hidden in *Earths*, *Stones*, or in other *Ores*, as in *Matrices*: if then these *Matrices* of themselves melt in the Fire with very great difficulty, or not at all; the Ore contained in them, may indeed of its own Nature be put in fusion; but yet it cannot be thus delivered of its Matrix, because this is not fusible. Such are for Instance iron-*Ores*, which by their Nature are always difficultly melted, and on this Account render other *Ores* difficult to be put in Fusion, when they are naturally intermixed with them. It is the same with almost all the *Stones* and *Earths*, a few only excepted, which are ranked among the vitrifiable ones: nor are these all of them very easy to be melted: for though they are put in Fusion by Fire; they most commonly become at the same Time so clammy, that they hinder the Precipitation and Ex-cussion of the small metallick Masses. The Lime-Stones (§ 30), and those that are not affected by Fire (§ 31), render the *Ores* intermixt with them most stubborn of any; so that they cannot be perfectly melted with Fire alone, even the most violent. Of these two the latter are still worse than the former. What we have hitherto said, is equally understood of all *Ores*, whatsoever they may be.

337. Some of the *Stones* just mentioned (§ 336.) are much lighter than the *Ores* intermixt with them: so that these may be easily removed, either by only pounding, washing and extinguishing them in Water, or by a previous Calcination, leaving the weightier Particles of the Ore at the Bottom of the Vessel

Vessel or Trough. These kinds of Ores are called decantable, (in German *Schiedige*.) They are known to be such: 1. from the great specifick Gravity of the Ore, which shews us that the metallick Masses, adherent to its Matrix, are large and solid, not too small and dispersed. 2. From the Lightness of the stony Matrix. 3. From the Brittleness of the same, either natural or procured by burning it, or by extinguishing it in Water, which Brittleness renders the Comminution easy. In this Case however, it is proper that the Ore itself be sufficiently fixt, and do not fly away by burning, or at least that it should thus melt into small spheroidal Masses. Among simple Stones, the vitrifiable ones (§ 29.) and the calcareous (§ 30.) are of this Kind; and among those that are not affected by Fire (§ 31.) the chalky, and other soft, light, brittle Stones.

338. But when Stones containing an Ore in them, cannot be separated from it by the above-mentioned (§ 337.) Helps, they are called indecantable, (in German *Unschiedige*.) Such are light brittle Ores, that contain a great Quantity of Sulphur, and are interspersed with the minutest Masses of the largest Surface of the Particles of the Matrix, or inclosed in a ponderous, hard Matrix, especially of that kind that cannot be affected by Fire (§ 31), and which neither Fire nor Water can split.

339. Finally, if there is in the Body of the Ore itself any thing intangled, or only adhering to its Outside, that will cause the Metal contained in it to vanish into a Vapour, or turn into *Scoria* with itself, while the Ore is exposed to the Fire, then such an Ore is said to be hungry, *minera rapax*. The Causes of this are commonly Arsenick, Antimony, and those Minerals out of which Zink is produced.

340. The three Differences hitherto explained (§ 334—339.) must always be chiefly regarded, in the distinguishing of all kinds of Ores: Therefore unless you may be certain of them by outward Signs,

you must always do your utmost to find them out by other Experiments.

341. As Metals and Semi-Metals are specifically the most ponderous of Mineral; and the Sulphur and Arsenick, with which the former make up Ores, are none of the lightest; it is self-evident, that pure solid Ores distinguish themselves from the other compound unmetallick Minerals, by their great Weight; only a few Pyrites very sulphureous (§ 316.) excepted. I say pure solid Ores: for when these are dispersed here and there, in small Quantities, among large Masses of Stones and Earths, they can never be distinguished by their Weight.

Of IRON, and its ORES.

342. As *Iron* is mixt with all Ores, is present almost every where, perfectly known, and manifesting itself easily, wherever it lies hidden, it deserves to be placed here at the Head of the rest.

343. Pure native Iron, if there is any to be found in the mineral Kingdom, is indeed of the utmost Scarcity. They take for Iron of this Kind, small octoëdral Stones, as likewise Cubes that are alone, or grown together among themselves many different Ways, having a Form like that of Pyrites of the *marchasite* Kind (§ 316), having sometimes Fibres like Wood; of a yellow, rusty, brown, dark Colour, very rich in Iron indeed, but yet having, under the Hammer, neither the Ductility of common Iron, nor the Hardness of *Steel*: For which Reason, they are to be reputed rather Ores very rich in Iron, than pure native Iron.

344. But the Ore of common Iron has no certain Form; being altogether irregular, most commonly of a rusty Colour, having but a middling specifick Gravity among Ores. It is easy to extract good Iron out of it. Its Brittleness, Hardness, and Weight, are sometimes greater, sometimes less; and the red Co-

lour,

lour, sometimes deep, sometimes light, shews how much Iron it contains in it.

345. There is also an Ore, which is very ponderous, and of a red bluish Colour, when broken, and which resists the Hammer by its Hardness. It is very rich in the best kind of Iron, and commonly yields in the first Fusion, from sixty to eighty Pounds weight of Iron, in the Center, or an hundred Weight.

346. There is a singular Species of Iron-Ore, which has the Figure of Spaad (§ 30, 1): it is of a pale yellowish Colour, though not uncommonly grey, and even sometimes of a half transparent White; it yields in the Fusion about thirty hundredth Parts of the best Iron, though the outward Sight of it affords no probable Sign of it whatever.

347. The yellow Pyrites (§ 316.) has indeed been referred to the sulphureous Minerals; but the Proportions of Iron and Sulphur being so inconstant in it, that it is sometimes the latter, sometimes the former which predominates in it, it may also be properly numbered among Ores: though, it is hardly ever exposed to the Fire, to have Iron fetched out of it, because there are Ores more abundant in this kind of Metal.

348. If you compare the Iron-Ores hitherto (§ 342—347.) described, with the Ores of other Metals, they are indeed refractory: but those which are to be called the most fusible (§ 334.) among Iron-Ores, are those that contain but little Sulphur, or sulphureous Acid in them; which is betrayed by the Smell that strikes the Nostrils, while these Ores are made red hot.

349. The Hæmatites (called in German *Blutstein*, *Blaskopf*, and in English *Blood stone*), is of a more refractory Nature in the Fire. As it is gibbose and arched in part, and partly angular and rectilineal, consisting of Planes directed towards one Point, on this Account it looks like an irregular Pyramid: which will appear much more so, if you break it. The Outside of it is pretty well polished, when the
Rust

Rust has been first wiped off; but the Inside is composed of convergent Striæ like the Amianth. If you break it in a transverse Direction to its Striæ, it is like the breaking of Steel that is not tempered very hard. It is of a dark red Colour, very heavy and hard. Moreover, it is almost the purest Iron-Ore, and mixt with a very small Quantity of Arsenick *. But it is rendered refractory, by a kind of Earth not to be affected by Fire, which may happen to be concealed in it. On this Account, the white Regulus of Iron, which is brittle, and very difficult to be rendered malleable, requires the greatest Fire to be melted.

350. *Smiris* (in German *Schmergel*, in English *Emery*, and in Dutch *Amarill*,) is the hardest of all the Iron-Ores that are known: it is a little less ponderous than the Blood-stone, very refractory, of a brown Colour, and really contains Iron; though the extracting of it is not worth the Charges: Wherefore Workmen pound it only, and use it to polish Steel: it is likewise employed to cut Glass, and polish certain Jewels.

351. *Magnesia* (in German *Brunstein*, in English *Manganese*) is here and there nicely striated with convergent Striæ: it has no certain Figure, and is of a greyish black Colour. It is frequently met with in Iron-Mines; and itself contains Iron; but the extracting of the Iron out of it by Fire, never answers the Charges, it being rapacious, and yielding no other but friable Metal. It is of greater Use among those that make crystal-Glasses, to take away their green or blue Colour, and to abate their too great Transparency.

352. There is a kind of Ore not unlike the foregoing (§ 351), which is of a dark grey Colour, shining, striated, and also containing Iron, but rapaci-

* Some Sorts of *Hæmatites* are so very rich in Iron, as to be capable of taking so fine a polish, as to look like burnished Steel, particularly a kind called in Italian *Pietra di Nicola*.

ous, and arsenical: for which Reason Metallurgists do not extract Iron out of it. It is called in German *Eisenman, Eisenglimmer*.

353. There is also, but especially in Tin-Mines, a kind of striated Ore, made of Filaments of an irregular Texture, and dark coloured, which, when scraped, appears sometimes of a dark red Colour: it is ponderous enough, and likewise contains Iron, but it is at the same Time very arsenical; on which Account it is always rejected by Metallurgists, as being very prejudicial. The Germans call it *Woolfram*.

Scholion, *The Iron-Ores hitherto (§ 342--353.) mentioned, as well as all the other Minerals, are called by different Names, which often signify but one and the same: and as these Names vary in all Places, it is impossible, and would even be superfluous, here to mention them all: Especially, because many of the said Names are derived from a Comparison very often defective, of Figures observed hardly once or twice, and of course very little essential. Therefore you will see Pepper, Beans, Peas, Confections of Coriander, Cinnamon, Iron, &c. reckoned among Iron-Ores, by Authors curious of trifling Matters.*

354. We shall also class here the Oker of Iron, which seems to have its Origin from comminuted Iron-Ore, and especially from the yellow Pyrites destroyed. It looks like a kind of fatty Earth, it has the Colour of Rust, which nevertheless is rendered sometimes yellow, sometimes darker, by a Mixture of other Earths; this occasions a Variety, in the Weight of this Oker. It is found both in dry and marshy Places; it forms here and there whole Veins and Strata, and is likewise found, though impure, in almost every Place, as in Marls, Clays, and Boles. This Oker is so very rich of Iron in several Parts, that it answers equally the Charges of extracting, as the best Iron-Ore.

355. Red-Lead, or red-Chalk, seems to be descended from this kind (§ 354.) of Oker, and to have been hardened by a Mixture of Bole and Clay. It is
of

of the reddish Colour, of a middling Weight, tender, so that it may be easily scraped and figured with a Knife; it has a soapy Feeling: when exposed to a great Fire, it grows very hard, and assumes a darker and shining Colour; it contains much Iron in it.

356. It has been observed, that whenever Sand is of a blackish Die, it has Iron or Lead in it. But its great Weight shews, that it contains a considerable Quantity of Metal.

357. We might very well range in the same Class, all native vitriolic Minerals; such as the stalactic Vitriol, and the Stones used for the making of Ink: for they either are purely of Iron, or at least, consist in great Part of Iron corroded by the Acid of Sulphur. We might also place here the *Lapis Calaminaris*, and many other Minerals; but as the several Metals drawn out of them, require each a special Management, we shall treat of them more at large hereafter.

358. The Mineral called *Flos ferri*, or Blossoms of Iron, is nothing but a Stalactites (§ 30, 3), resembling a Germination like that of Corol. It is called *Ferri Flos*, because it has now and then been found about a calcareous Iron-Ore: Nor does it seem to deserve this Name, upon any other Account.

359. There is found, in several Iron-Mines, especially those of *Sweden* and *Norway* *, an Ore called the *Magnet* or *Load-stone*: which is a black ponderous Stone, not very hard, when pure. It is often intermixt with Flints and Spaad, in which Case it is less good. You may see the wonderful Properties of this Stone, mentioned in the Writings of Naturalists. But we shall here chiefly treat of that of its Qualities, by which we may find out the occult Presence of Iron. The Load-stone attracts Iron at a great Distance, and holds it strongly to itself, unless an excessive Weight, or some other Obstacles hinder the Effect; nor is there any other Body but Iron, that is attracted in

* And in many Parts of *England*, whereof several Specimens are to be seen in the *Museum* of the *Royal Society*.

this Manner by the Load-stone; as has been evidenced by a Multitude of Experiments made with it. Now, whether any Body contains Iron in it or no, we find with the Load-stone in the following Manner. You first reduce the Body to be tried into a fine Powder: which must be done in a Brass-Mortar, especially if the said Body be hard, but never in an Iron one: then you put this Powder into a Crucible, having a Cover to it, and well luted, either without any Addition, or, for greater Security, with a small Quantity of Tallow; and make it red hot for about an Hour in a strong Fire. When it is grown cold, if you extend it upon a smooth Paper, bring the Load-stone itself, or its armed Iron-Poles near to it *. If there are any Iron-Particles in this Powder, they will apply themselves either to the Load-stone itself, or to its armed Poles, and hang on it like Beards. When you see this, wipe off the adhering Particles, that they may fall asunder, and then put the Load-stone again into the Powder, and move it up and down. By the same Thing often repeated, you will at last have taken away all the Iron, leaving only the Particles that partake not of Iron.

360. But there are very few Iron-Ores attracted by the Load-stone, before they have been made red hot in the foregoing (§ 359.) Manner, not excepting even the Blood stone (§ 349), though ever so rich of Iron. Which is the more wonderful, because Iron, though adulterated with other Metals, or Semi-metals, and even mixt with Arsenick, is not thereby rendered altogether unapt to be attracted by the Load-stone. *Antimony* is the only metallick Body, that can hinder this Action. *Sulphur* can hardly hinder it, because the Blood-stone just mentioned, red Chalk, Oker, and the more solid Iron-Ores, that are not of the Pyrite kind, lose but very little, and some of

* If you have not a Load-stone at hand, the Blade of a Knife or any other polished Piece of Iron which hath been touched on a Load-stone, will have the same Effect, but not so strongly.

them nothing at all of their Weight, by being burnt in the Fire. Nor does it seem probable, that there is any Antimony hidden in all these Minerals. But what makes this Matter more obscure is, that the Blood-stone, red Chalk, and some other Iron-Ores, without adding any phlogistical Matter to them, are rendered capable of yielding to the magnetick Virtue, by being only made red hot in a Vessel well closed; while, on the contrary, the other Bodies, when made red hot, require the Addition of a more fixt Phlogiston, without which the Load-stone would have either no Iron at all, or a much less Quantity of it to attract. On this Account, there have been two Opinions espoused by Authors. Some are of Opinion, that mineral Sulphur, and the Acids adhering to Iron, hinder it from being attracted by the Load-stone; and that consequently they must either be dissipated or changed, to restore to Iron its magnetick Virtue. But it is repugnant to their being dissipated, that some Ores made red hot in close Vessels, without any Addition, and losing not the least Part of their Weight thereby, yet become capable of being attracted by the Load-stone; as it is repugnant to their being changed, that mineral Sulphur, and its Acid, are never altered in close Vessels, by Fire alone, without any Addition; and that on the contrary the sulphureous Acid, with an Addition of a true Phlogiston, regenerates the true mineral Sulphur, which nevertheless is supposed to resist the Action of the Load-stone. Now the Phlogiston made red hot with Iron-Ores, is very proper to revive the Attractibility: Nor can this be any way obtained, when the Ustulation is made with pure alkaline Substances, that really change the Acid of Sulphur. The other Opinion, taken from the Decisions of the illustrious Mr. Stahl, is, that Iron is ingendered by a Phlogiston, mixt with a ferruginous Earth, by Means of Ustulation: which will appear the more probable, if you attend to the following Considerations. 1. The Ores and Earths which being made red hot without
any

any Addition, are not attracted by the Load-stone, if you melt them either alone without adding any Phlogiston or only by Means of an unphlogistical Flux, in the strongest Fire, will turn into a metallick Glass, not into a *Regulus*. 2. With this Glass, and by Means of a due Addition of Phlogiston, you will produce the most perfect Iron in the Fire. 3. Iron destroyed by Acids, Fire, or any other Means, or only turned into Rust, is not attracted by the Load-stone: and then when it is melted by a strong Fire, without adding Phlogiston to it, the same Thing happens, that was mentioned (N^o 1). Whence it is plain, that by an inflammable Oil, Iron is produced from what was no Iron. See (§ 90—95). Nor is it a Contradiction to this Opinion, that some Ores receive a magnetick Virtue, though made red hot without any thing added to them. For nothing hinders the Phlogiston, which is necessary to constitute the metallick Nature, from being already present in the Ore, though it be not as much united with the fine Part that constitutes the Iron, as is required to give it its metallick Form: so that it is necessary previously to unite it thereto by the Action of a strong Fire; which is always requisite in all Reductions.

Of COPPER, and its ORES.

361. Native Copper, that is, Copper in its metallick Form, is found much more frequently and more perfect than Iron. However, it is yet somewhat less malleable than Copper well forged.

362. It must be observed of Copper-Ores in general, that none of them distinguishes itself by any certain Figure, but that they are almost all of them irregular. But the finest Colours of any Kind, red and the diaphanous Colours excepted, most commonly betray the Presence of Copper, when they are to be seen in any Ore. For this Reason, there is hardly any Copper-Ore, that is not mixt with Iron in greater Quantity, than the Ores of other Metals commonly are. Nevertheless, there is a much less Quantity of

it in some of them, than in others. But we reckon those that contain less Iron in them, to be naturally more fusible than the rest. Such are,

363. The vitreous Copper-Ore (in German *Kupfer Glas-Stein*). This is of a darkish violet sky-Colour, like that of a Piece of Steel that has touched a red hot Iron. Besides, this Colour is commonly interrupted here and there by Spots and grey Veins. It is very ponderous, and of a middle Hardness. One hundred Pound Weight of it, contains from fifty to eighty Pound Weight of Copper.

364. The azure Copper-Ore, is of a most beautiful blue Colour; it is soft, not very heavy, broken, shining like blue Glass; of all the Copper-Ores it is the most free from Iron, *Arsenick*, and *Sulphur*, though it exhales a little of the latter in the Ustulation: wherefore, a great Quantity of excellent Copper, is extracted out of it with very great Ease.

365. The green Copper-Ore is like green Crystals, often very neatly striated: it looks almost like a Germination*. As for the rest, this Ore has the Properties of the (§ 364.) foregoing.

366. The light, dusty, blew Concretes, *Cæruleum Montanum*, in German *Bergblau*, and the green ones, *viride montanum*, less properly *Gold-sodder*, in German *Berg-grun*, being also called both by the Name of *Copper-Okers*, yield a great Deal of very good Copper, when they are pure, which appears from the Colour and Weight of them. But the lighter ones are mixt with unmetallick Earths: those that are yellow contain Iron-Oker: on which Account they are more difficult to be melted, and yield less Copper, and of an inferior Goodness. This Mountain-blue, and the green are carried here and there by Waters, and apply themselves to the Outside of Lumps, like a Paint.

367. The white Copper Ore, in German *Weis-Ertz*, has been hitherto found only in one single Mine of

* Some of this Copper-Ore germinates like the Blossoms of Iron (§ 358), looks like white Coral tinged of a bluish green Colour, and may as properly be called *Flores Cupri*, or Blossoms of Copper.

Misnia; the grey one, in German *Fahl-Ertz*; and the dark ash-coloured, in German *Fahl Kupfer-Ertz*, described by *Henckel*, in *Pyritol.* Pag. 195, 197, are solid, ponderous, and rendered white by Arsenick. The first Species is distinguished from the white Pyrites (§ 323), by a Colour somewhat yellowish, but the others are distinguished from it, by a much darker Colour: They at the same Time are all distinguished by their greater Weight, and breaking smoother: which is more exactly perceived, when you compare together the native Specimens of the Bodies to be discerned.

368. There is also a Copper-Ore, called by some Vitrean, and possibly not very different from that above described (§ 363), except in the Quantity of Iron it contains: on which Account it is harder than the former, and of a darker Colour: it melts with greater Difficulty than the foregoing ones, and is nevertheless very rich in Copper. We must likewise rank in the same Class, that kind of dark red Ore which is almost of a Liver-Colour, and which is not easily discerned by the bare Sight, from an Iron-Ore of the same Colour.

369. The merely sulphureous Copper-Pyrites is of a yellow Gold Colour, with a light Tincture of green, both within and without; if you break it, the Inside has a kind of granulated Surface; it is easily beat into Powder, and contains Sulphur and Copper in many different Proportions, whence its specifick Weight varies likewise very much. But if it is very rich in Copper, and at the same Time mixt with any Quantity of Arsenick, its Gold-Colour becomes yellowish, and when you break it, the Surfaces are smoother, neater, and more even. In this Case, it is called in German *Kupfer-glantz*. Very often, it is of the brightest Green and Blue, both at the Outside, and between the Chinks: Nevertheless, if you break it, and thus display a new Surface, these Colours seem not to penetrate through the whole Substance of it. But when the Copper Pyrites are mixt with a consi-

derable Quantity of Arsenick, they then look pale, like the sulphureous Copper (§ 316.) Pyrites; and even are whiter than this, according as the Quantity of the Arsenick is greater. Nevertheless, they, even in this Case, are distinguished from the Iron-Pyrites, because they are more ponderous, and give not Sparkles so easily, if even they give any, when struck with a Steel: which every Iron-Pyrites (§ 316, 323), and any solid Iron-Ore will do.

370. The Reasons why the Copper-Ores above-mentioned (§ 363—369 are rendered refractory, and even entirely unfusible, are explained (§ 336).

371. The yellow sulphureous Iron-Pyrites (§ 316.) belongs likewise to this Class, though improperly. For it often contains in it a Quantity of Copper, not to be despised, but it is looked upon as improper to Copper, and as very refractory, on account of its great Quantity of Iron. ~~In~~ the mean Time you find out whether it contains Copper; 1. From its not being of a globular Figure: for it is evident from the Observations of *Henckel*, that globular Pyrites are altogether destitute of Copper. 2. From its unusual Yellowness spreading through the whole Substance of it.

Coroll. From the above-mentioned (§ 369, 371.) Particulars, we may easily deduce some Rules, whereby we shall be able positively to affirm, that a Pyrites contains Copper in it. For Instance, let this be a Rule: *The gold greenish Colour of a Pyrites is a Sign of its containing a great Quantity of Copper*: which is confirmed by Experience. But you cannot by any Means invert this Rule thus: *If a Pyrites contains a great Quantity of Copper, it is of a gold greenish Colour*: because when Arsenick is mixt with a Pyrites, even one that is very rich of Copper, it makes it entirely look pale (§ 369). The same may be said of every such Rule.

371. The Ore which has been mentioned (§ 328), under the Title of *Kupfer-nickel*, when we treated of Arsenick and arsenical Minerals, may have a Place

here, but only as being improper. It contains a Quantity of Copper not inconsiderable, but it is neglected, because the Cobalt, wherewith it is incumbered, renders it almost untractable. In the mean Time you are to observe, that what renders Ores intractable, is not the Arsenick itself, but a kind of Earth, which is always united to the proper Minerals of Arsenick, especially to Cobalt (§ 325), which resists Fusion very much, and by Means of the Arsenick that is fixt in it, adheres with great Tenacity to Metals, especially to Copper and Iron.

Of LEAD and its Ores.

372. There are very few Instances, of native Lead's existing naturally pure and malleable, among other Metals.

373. *Galæna tessellata*, or the Cubic Dice-Lead Ore, called in Germany *Weyglantz*, is an Ore very rich of Lead, consisting of a Quantity of small equilateral Cubes, or of oblong Parallelopipeds. But these Cubes are, as it were, composed of very thin, well polished Lamina's, that shine very bright, and are of a blackish blue Colour. However, this Ore is very ponderous, soft, and brittle; it is more fusible than a great many other Ores, though it requires a much greater Fire to be melted, than Lead itself: the Cause of which is the Abundance of Sulphur, that lies hidden in the Lead-Ore, and constitutes almost one quarter Part of it. In a Fusion well managed, one hundred Pounds weight of pure and solid Lead-Ore, will yield from 65 to 70 Pounds weight of Lead.

374. If the Lead-Ore (§ 373.) consists of small, thin, oblong Cubes; when broken, it appears finely striated, and is called in German *Klar Spiessiger Weyglantz*.

* Some pure native malleable Lead hath been found at this Day in *New England*. What is commonly taken for native Lead, is really a very rich, somewhat malleable Silver-Ore of a lead-Colour. See (§ 385).

Scholion I. You will always see this cubical Figure (§ 373.) in the Lead-Ore; nor was ever any other Figure observed in it, except such as had been given it by some external Power or Resistance; for, even in this Case, it has always the same Form within. But Lead-Ores are called by different Names, according to the various either regular or irregular Application of the Cubes to each other, according to their Magnitude, and their Brightness thereon depending, and to their Surfaces, whether smooth or rough and granulated. There is also a Difference observed in them, as to their Colour; some being of a lighter and more bright Colour, and others of a darker blackish Dye.

Scholion. II. Lazarus Ercker, pag. 161. mentions a red kind of Lead-Ore, which he says is ponderous and like red Clay. But I found that this red Mineral, which appeared to me to be Lead-Ore, and has been falsely mistaken for Cinnabar, was nothing more than the Lead-Ore, having here and there larger Cubes, easy to be distinguished by the Eye without any Help, and an infinite Number of very minute Ones, not to be seen without a Microscope, and lying hidden in a red marly Kind of Earth: so that it does not constitute a particular Species. The same Author mentions in the same Place another Lead Ore, resembling a white sandy Stone. There are also sandy Rocks, now and then very rich of Lead; but which being well examined, contain an Ore not in the least different from that described (§ 374). The Rock indeed, which is most commonly soft, and on this Account does not deserve to be called Rock, bears a true Lead-Ore which is irregular on the Outside, looks globular, and is filled throughout the Substance of the Rock, with small Masses of very various Sizes, and not very bright: so that when the Rock is broken, there appears the perfect Species (§ 373) of Lead-Ore. Abundance of these are digged out of the Mines at Breybach.

375. The Stones that are of a lighter Colour, especially the Flints and their like (§ 29, 4), when they are mixt with ash or black Colour, or only marked here and there with Veins and Spots of the like Dye, thereby

thereby shew that they contain either Iron or Lead in them. They, in the first Case, are called by the *Germans Eisen-Schweifig*; and in the second Case *Bley-Schweifig*. But they, by the Word *Bley-Schweifig*, understand in a special Manner, sulphureous arsenical Lead-Ore, which on this Account is rapacious, of a yellow Colour, intermixt with ash-coloured or blackish Spots, and somewhat fattish to the Touch.

376. The green Lead-Ore, is very rare, of a yellowish green Colour very much varied, and half transparent. It varies its Figure, though it most commonly has that of Spaad, shutting in Form of Nitre, but less regular. It is likewise ponderous, not hard, and at the same Time very rapacious. Nevertheless, one hundred Pound weight of it yields from 70 to 80 Pound weight of Lead. The white and ash-coloured Lead-Ore are looked upon as being like this, and are every bit as rare.

377. The Lead-Ores hitherto (§ 373—376.) mentioned, are never rendered refractory by a Mixture of Iron-Ore, or of the sulphureous Iron-Pyrites (§ 316), as are the other Ores (§ 336): for unless the Ore that contains Iron, be naturally associated to the Lead-Ores, the major Part of Assayers, in order to roast them with greater Ease and Benefit, commonly use an addition of Iron, or of its fusible Scoria's that are still reducible. Of this, more at large, when we are upon the Operations. However, the white arsenical Pyrites (§ 323), if it is ever thought worthy to be classed among Ores, ought in this Case to be excepted, partly on account of its Rapaciousness, and partly on account of the refractory Quality (§ 325.) of the abundant terrestrial *Caput Mortuum*, that remains of it after the Arsenick has been blown away.

Of TIN and its Ore.

378. That Tin ever existed naturally in a true metallick Form, is very uncertain, or at least, it has been

seen very seldom. Nevertheless, *Matthæsius* says, that the Thing has happened sometimes.

379. The most rich Tin-Ore is of a black or dark Colour of a polyhedral, but altogether irregular Figure; having its Surface very glossy. This surpasses almost all the Ores of the other Metals, in its specifick Gravity†: which seems to be the more wonderful, because Tin is the lightest of all Metals. But as Arsenick is exhaled almost pure out of this Tin-Ore in the roasting, and as the Part of it that remains after the roasting (if you consider how much of the Tin is destroyed during the whole Time of the Reduction) is to be reckoned purely metallick; it is easy enough to guess at the Cause of this Gravity. As for the rest, it is of a middle Hardness, and, with regard to the Tin itself, is very refractory: for it sustains a quick Fire, without either melting or growing clammy; and if you expose it to a sudden Heat, it neither bursts violently nor crackles, except when an Experiment is made upon large Lumps, among which other Ores, or some Stones, especially of the Quartz-Kind are intermixed. This Ore is called in German *Zinn-Graupen*, in English *Tin-Grains*.

380. The most common Tin-Ore, called in German *Zwitter*, is of a dark yellowish rusty Colour: so that on this Account it cannot, by the bare Sight, be easily distinguished from the Iron-Ore; especially as it contains itself Iron. The Figure of it is irregular, and agrees in every Respect with that of the foregoing (§ 379); for which Reason it seems to be another of the same Kind, and to differ from it only by its Degree of Purity.

381. We may, after having explained (§ 379.) what happens to the Tin-Ore in the Fire, find out by an Experiment made *ex tempore* in the following Manner, whether there is any Quantity of this Ore contained in any Lump offered for Trial, and about

† Infomuch as sometimes to have a greater specifick Gravity than a Piece of Tin of the same Size melted from it.

what Part of it lies hidden therein. Pound the Lump into a Powder not very fine, and wash off from it with Water the light terrestrial Filth that is in it. Then upon a flat, not over broad Shovel, made quite white hot, and having not a high Border, sprinkle your Ore, after having pounded, washed, and dried it, and divide it in such Manner, that it may not be heaped up in any Place, but quite spread: This must be done, that all the sprinkled small Parcels of the Ore may grow red hot quick enough, and that the small Stones which may happen to be under or intermixed with them, may not, in their flying asunder, carry a considerable Quantity of the Ore away with them. Thus the small Stones will be dissipated with a gentle Noise, as also the heavy intermixed Ores of other Metals that are less well washed; because there is hardly any of these, that can bear a sudden Heat: There will remain the Tin-Ore, become of a reddish Colour, and covered with a kind of of grey arsenical Flowers.

382. The Garnate is reckoned among precious Stones: its of an unsettled Figure, though most commonly dodecaëdral †, regular enough, not rare, half transparent, and having its Name from the Flowers of Pomegranates of which it has the Colour. This now and then contains Tin; so that on this Account it deserves to be reckoned among the Ores of this Metal. Nevertheless, all kinds of Garnates ought not to be referred to this Class. For they sell, under the same Name, Stones that have indeed the same Colour, but are more transparent, vitrescent and are rather of the Nature (§ 29, 4.) of Flints.

383. The Tin-Ores mentioned (379, 380.) which are rendered refractory by the Stones and Earths mixt with them, may among the other Ores be very well improved by washing and roasting, on account of their considerable Weight, and Constancy in a middle Fire. But they can never be totally freed

† Or composed of twelve Sides.

from the Iron-Ore, especially that kind of rapacious Iron-Ore, that was mentioned (§ 353), which is very often intermixed with Tin-Ore. For this Reason, the Tin melted out of these Ores, is less perfect and true than that yielded by a pure Ore. For Iron mixt with Tin, turns into a hard untractable (§ 59.) *Regulus*, that can never be separated with any Benefit. The Copper-Ore, likewise, is sometimes found mixt with Tin-Ores, under the Form of Oker, or of Pyrites: it renders the Tin extremely brittle, when it melts together with it in any considerable Quantity: But this Ore is more easy to be fetched out by washing and roasting, than the Iron-Ore.

Coroll. From what has been just (§ 383.) said, you may easily guess, what kind of Tin any Ore will produce; and why English Tin is the best of all. For its Ore is, of all Tin-Ores, that which is less defiled with Iron.

Of SILVER, and its Ores.

384. Pure ductile Silver, not defiled by Sulphur or Arsenick, is found naturally and much more frequently than the foregoing Metals, in small Masses of many different Figures, especially under the Form of Filaments and Scales, in many various Stones, and Earths, and in several Kinds of Sand, that are even exposed on the Surface of the Earth *.

385. The vitrean Silver-Ore, is of an irregular and altogether unsettled Figure. It is very ponderous, easy to be flatted with the Hammer, and to be cleft, not much harder than Lead, and much of the same Colour; it melts presently, and soon grows red hot †. It consists of Sulphur and of pure Silver: which the Regeneration of it (§ 140.) and the Che-

* The most beautiful is in thin Plates with various Furrows on them, so as to make the Plates resemble real woven Silver-Lace.

† This is often mistaken for native Lead. See the Note to (§ 372.)

mical Analysis shew. It contains above three quarter Parts of Silver.

386. The horny Silver-Ore is half transparent, it is of a deeper or lighter yellow or brown Colour, according as it consists of larger or smaller Lumps, it looks like Rosin, and has an irregular Figure on the Outside; but when examined closely within, it appears to consist of very thin Plates. Nor is it very ponderous, nor hard, but easy to be ground: when brought suddenly to the Fire, it crackles, bursts at a great Distance, as most Ores do, and in this Case exhales a sulphureous Smell, and sometimes burns lightly, and finally casts forth something arsenical, but in a very small Quantity. On this Account, it seems to differ from the foregoing (§ 385), at least with regard to the Quantity of Sulphur. For it hardly contains two thirds of Silver in it.

387. The red Silver-Ore, is of a scarlet Colour, sometimes lighter, sometimes deeper *; in the first Case, it is transparent like the arsenical Ruby; and in the second Case, it is of a deeper Dye. It varies its Figure, though it is often of the crystalline prismatical Form; it is heavier than the foregoing (§ 386.) horny Silver-Ore; but it bursts, when brought near a Candle, or a mild Fire, and the remaining Part of it melts immediately, before it grows red hot; and then it emits the disagreeable Smell of Arsenick, together with a thick visible Smoak: It has something sulphureous in it, which is evidenced by its burning violently and by the Smell of the nitrous Acid, which rises from it when you sprinkle upon it Nitre put in Fusion, and made red hot: which Phænomena are the Effects neither of the Arsenick, nor of the Silver; so that the scarlet Colour of this Ore seems to proceed from this Cause (§ 148.) You may sometimes extract with the Load-stone

* Much resembling a Garnate, and hath by its outward Appearance been mistaken for transparent Cinnabar. See the Note (§ 402.)

(§ 359.) out of the *Caput Mortuum* of this Ore, some Iron remaining after the Sublimation made in close Vessels; though you use the choicest Bits of the Ore for this Experiment. However, it has in it the same Quantity of Silver, as the horny Ore above-mentioned (§ 386.)

388. The white Silver-Ore, of a light grey Colour, of an irregular Figure, pretty ponderous, and very brittle, has at the same Time some Copper in it; nay, it even contains most commonly more Copper, than Silver: so that it differs from the white Copper-Ore (§ 367.) only on account of the Quantity of Silver it contains. It is heavier than the two foregoing (§ 386, 387.) yielding however less Silver than they. The Lead-Ore, especially the granulated Ore (§ 373), which is of a lighter Colour, is sold for it. See *Henckel's Pyritol.* Pag. 170, 195.

389. We have not hitherto known any besides these four (§ 385—388.) Silver-Ores, though many others are looked upon by some, as such: However, the Thing being well examined, they either are improper to Silver, or prove to be composed of the already mentioned proper Silver-Ores; that is, sometimes of them all, and sometimes of only some of them, mixt together in many different Proportions. And this Mixture is sometimes so very subtle, that it can hardly be perceived with a Microscope. And indeed among the Iron, Copper, Lead, and Tin-Ores, already explained (§ 342—382), you will sometimes find some, that will yield no inconsiderable Quantity of Silver; but as these contain more of the other Metals, they, on this Account, must be called improper Silver-Ores, when they have any Silver intermixed with their Substance (§ 311.) or accidental Silver-Ores, when there is only some Silver adhering to their Outside (§ 311.)

390. The white and grey Copper-Ores (§ 367) may be called improper Silver-Ores, as they are always impregnated with Silver. But the other Copper-Ores, though they most commonly contain Silver, so,

so that there is sometimes a great Quantity of Silver got out of them ; nevertheless, cannot always be referred to this Class, unless you have, in some special Case, found out by Experiments, that they contain Silver in them: for we have not hitherto found out any certain Characteristicks, and outward Signs, from which we might decide, whether any Ores contain Silver in them, or no. And if any such Characters have been found out, they usually are regarded only with relation to the Mine that yields the said determined Ores: so that People that do not use the necessary Cautions, are often deceived in making an universal Application of such external Signs.

391. It is the same with the Lead Ores: for the more nicely striated, among these, the granulated Ores (§ 374), and those that have a changeable Brightness, are referred to the Class of the Ores that contain Silver: because, there is sometimes so much Silver in them, that it is of greater Price than the Lead thereto adhering. Some look upon them, and not without Foundation, as real Silver-Ores. But this Rule suffers a great many Exceptions; while, on the contrary, the Lead-Ore consisting of large cubical Parts, which is generally thought to contain Silver, is of equal Value to that of the foregoing, with regard to the Silver.

392. Finally, it is proper to forewarn every one, not to be overhasty in thinking, that there is generally Silver contained in the Ores of Copper, Lead, Iron, &c. because Silver may be extracted out of the Lump, in which this kind of Ore predominates, or out of the Metal that has been melted from it: nay, before you make your Experiment, and determine any thing, you must previously and with great Care chuse an Ore, perfectly pure, looking homogeneous, and altogether free within and without from any Mixture of Stones, that might perhaps conceal some Silver-Ores (§ 354 - 388). For unless you take such an Ore for your Experiment, you will never be able to conclude with certainty, from any Silver fetched
out

out of it, that it is fruitful in this Metal ; as there are very few Ores, that are not sometimes contiguous to Silver-Ores. But if such a Concretion has been made by minute Masses, you cannot easily perceive at first Sight, whether it is proper to the Ore, or only accidental. Hence the Reason may be understood, why *Regulus's* precipitated separately and at different Times, out of impure Bits of Ore, when tried, do not yield at every Time the same Quantity of Silver, in proportion to that of the Metal, though no Errors are committed in the Operation ; which never happens, when the Ore is well beaten and mixt before, or when you use it perfectly pure.

393. The pure (§ 384—388) proper Ores of Silver, either those that are incorporated with some pure Copper or Lead-Ores, or those that are only intermixed with them, are of themselves fusible. Now, what Ores are refractory and not fusible may be understood from what was said before (§ 334), as it holds equally true of all kinds of Ores. But the Tin-Ore requires here a particular Consideration : for, in the Fire, it is refractory neither alone, nor joined to other Ores : nay, Tin may be very easily mixt with Silver, but above all with Lead (§ 41 and 57): However, it sometimes happens, that, as soon as you increase the Fire, so as that the Lead may grow red, the Tin separates from it (§ 41.) in form of Calx ; which Calx is altogether indissoluble by Lead, and with great Difficulty dissolved by the Glass of it, and takes away a great Quantity of the Silver, when this has been mixt before with Tin. But Silver is, by Lead, washed off with a strong Fire, from all heterogeneous Metal, Gold excepted. Whence it is plain, that Silver and its Ore, when Tin or its Ore is mixt to it, must be looked upon as refractory, and for what Reason.

Of GOLD, and its Ores.

394. *Gold*, whose Characteristicks are very (§ 6.) remarkable, is free from Sulphur and Arsenick; of all other Metals it is most frequently found native; has no certain distinctive Figure, and consists only of small irregular Masses. It will not be improper here to mention at least its principal *Matrix's*.

395. There is a *Flint*, or *white Quartz* (§ 29. N° 4.) in which Gold commonly lies hidden in very solid and large Masses. It is concealed likewise, but more seldom, and in less Quantity, in that yellow and blue kind of Stone, which some call the *Lapis corneus*.

396. That kind of blue Stone, which may be cleft, and, on Account of its Colour, is called *Lapis Lazureus* †, often most elegantly sparkling with very small Speckles of Gold: The Gold, nevertheless, is less solid in this Stone, than in the foregoing ones (§ 395.)

397. There is hardly any *Gravel* in the Nature of Things, that does not contain Gold in it: as do likewise several fat slimy *Earths*: But they are seldom rich enough in Gold to pay the Charges of extracting it therefrom by washing and Amalgamation. But that kind of Gravel which is found in the Channels of Torrents and Rivers, or near them, especially where the Canal makes many Windings, is commonly richer in Gold than all the rest *.

398. This *native Gold* (§ 394.) is very seldom found altogether pure; but is commonly mixed with Silver: Nevertheless, that which is found in the Gravel and Earths mentioned (§ 397), is rather more mixt with Silver than that which is wedged into a solid *Matrix* (§ 395, 396.)

† *Lapis Lazuli*.

* Such Gold Dust is to be found in small Quantities, in some of the Rivers of Scotland. At the Coronation of King Charles I. some Medals were made of this Gold, with this Legend round the Edge, *Ex auro, ut in Scotia reperitur*. One of which is to be seen in that admirable Collection of Sir Hans Sloane Bart. &c. and many of the Country People have gathered enough to make Rings of.

399. No Ore, that I know, hath been hitherto found, in which Gold constituted the greatest metallick Part; so that I cannot mention any Ore (§ 311.) proper to Gold. The same is testified by the Authors that are most skilful * in the Knowledge and Trial of Minerals. There are indeed several Ores sold under that Title; but which, after a strict Examination, are found not to be such; for in those Places where Gold is washed out from Gravel and Earths (§ 397.) you often find Tin Ores in Grains, as likewise the Garnates mentioned (§ 379—382.) In which Case the rapacious Iron-Ore, called in *German* (353.) *Wolfram*, which is commonly joined to these, is seldom wanting: Nay, it has sometimes happened, that many People deceived by the red yellowish Colour of these Ores, looking as if there was Gold in them, have mistaken them for Golden Ores: Mean while, I never saw any Body grow rich by Means of them, or any Gold melted out of them. The same thing is to be concluded of the *Golden Marchasites*; so called because they are nothing but sulphureous *Marchasites* † (§ 316.)

400. There are no Ores improper to Gold, but Silver Ores: For it is in these alone, that Gold penetrated with Sulphur and Arsenick, has divested its metallick Form. If Gold is found in other Ores, there is a much greater Quantity of Silver joined to it: So that they rather belong to the Class of the Silver Ores; among which they have already been reckoned.

Coroll. As Gold is most constant and incorruptible in the Fire (§ 6), its most subtle Particles are easily distinguished from Particles of the same Colour (§ 316):

* *Laz. Erck. Aula Subterranea*, p. 55. *Georg. Leonhard. Von Lochness; Nachricht vom Bergwerk*, p. 125. *J. F. Henckel Pyritolog.* p. 167, 226, 667.

† The *English* Miners confound the *Marchasites* and *Pyrites*; and generally call them by the common Name of *Mundicks*. See *Woodward's Method of Fossils*.

For the former not only retain their Colour in the Fire, but, if they have been defiled, they even become the more beautiful. Whereas the Colour of the latter changes entirely into a dark Red, and their shining Surface becomes dusty; nay, if there is then any golden Particles in them, they are but the more conspicuous for it.

Of MERCURY, and its Ore.

401. *Native, fluid, Quicksilver, called Virgin Mercury*, most commonly lies concealed in an ash-coloured soft Stone, easy to be cleft: In which it may be detected by the naked Eye, or by Means of Microscopes, under the Form of small Drops. It is found in great Quantity especially about *Idria* †, so that sometimes little Drops of it running together out of the *Matrix*, may be gathered in small Vessels.

402. There is but one single Ore of Mercury known, called *Cinnabar*; of which you will find very good Specimens in every Druggist's or Apothecary's Shop, under the Name of native *Cinnabar* *. It is of the finest scarlet Colour, and, when broke, appears striated with small parallel Furrows: Besides, it is very heavy and soft, and consists of mere Sulphur and Mercury; in such Manner however, that the Quantity of the Mercury is commonly above six Times greater than that of the Sulphur, and that the Beauty of the Colour of the *Cinnabar* depends on the Abundance of it: As the Regeneration and Chemical *Analysis* of *Cinnabar* shew. Hence the Reason is likewise evident, why this Ore is so very volatile, in comparison of other Ores.

† *Idria* is a Town in the County of *Goritia* and Province of *Carniola*. See Dr. *Brown's Travels*, Lond. 1687, Fol. p. 81.

* There is in *London* great Plenty of the finest native *Cinnabar* or *Quicksilver Ore* to be had, as yearly imported by the *East-India Company* from *China*; it is of a beautiful red or vermilion Colour, and Semi-transparent; resembling the red *Silver-Ore* (see the Note to § 387) but of a lighter Colour.

403. Mer-

403. Mercury, and its Ore, Cinnabar (§ 402.) is more seldom found than any Metal; so that according to the Calculations of Dr. *Hoffman*†, there is fifty Times more Gold got every Year out of the Mines, than Mercury or its Ore. This indeed is very true, but it seems to be no less certain, that Mercury and its Ore offer much more frequently than we think, but are not known to us. This will appear probable to any that will consider, that Metallurgists try the Minerals unknown to them, in a strong open Fire only, making with them Scorifications, Coppellations, and various melting Precipitations; and neglect, or perhaps are ignorant of those Operations that are made in close Vessels; because they hardly ever think of Mercury, except when Quicksilver itself, or the scarlet Colour of its Ore (§ 402) offers to their Eyes. Besides, the Colour, Weight, and Figure of Cinnabar (which is nevertheless most easily distinguished from other Minerals, when pure) are altered to such a Degree by the other Minerals mixt with them, that can never be detected by the mere outward View, and without making an Experiment.

Coroll. You will indeed find in the Works of Chemists, several Experiments mentioned, by which they say that Mercury has been fetched out of Minerals; but all these Experiments are here of little Service to us. For, 1. These Minerals are not exactly described; so that they could not be distinguished, if they should offer to us: And if they have been called by a Name, the same is also common to many other Things, or the Signification of it known to none but the Author himself. 2. The Particulars necessary in the relating of Experiments, have been almost entirely omitted.

† Dissert. Physico-Chemica, de Mercurio & Medicam. ex Mercurio selectioribus, Thes. II.

*Of the REGULUS OF ANTIMONY *, and its Ore.*

404. I am not certain from any Observation, that the pure *Regulus of Antimony* was ever found native; nor do I remember to have read in any Author, of its having been fetched pure out of the Mine.

405. The Ore of Antimony, is of the Colour of Lead-Ore (§ 373), it has very fine, long, parallel Striæ, in form of Needles, that cut each other across; and more seldom small shining Scales, with a light reddish Colour intermixed; it is heavy, and resolves partly into a *Regulus* (§ 16), and common Sulphur, out of either of which, it may likewise be easily regenerated (§ 333.) by a proper Operation.

Scholion. *The Description of the Regulus of Antimony (§ 404.) has indeed a very great Affinity with the Descriptions which we have given of some Iron-Ores (§ 351, 352, 353,) especially (§ 353); and there is indeed so great a Likeness between them, that they are sometimes confounded with one another. Nevertheless, it is easy to distinguish the Ore of Antimony from the rest, because a small Particle of it applied to the Fire of a Lamp, will melt immediately; which rapacious Iron-Ores can either not be put at all in Fusion, or at least not without using the Blow-Pipe (§ 258). Besides, when a Man has once exactly considered the external Habit of all these Mines, and filled his own Imagination with the Impression of it, he finds out a certain Difference, which Words cannot easily describe, but which is nevertheless so remarkable, that he is able for the future to distinguish them from each other, by bare Inspection.*

Of BISMUTH, and its Ore.

406. *Bismuth* lies sometimes inclosed so very pure in its Ore, that you need not use any other Opera-

* The common Antimony to be met with in Shops, hath undergone a Fusion from its Ore, and therefore our Author calls it *Regulus Antimonii*.

tion to fetch it out, but breaking of it not very fine †.

407. Every Ore of Bismuth, as is shewn by the Chemical Analysis, is reduced to the State of Ore by Arsenick: For this goes out of it by Sublimation. You find in the same Ore that kind of Earth, that gives an azure Colour to Glasses, of which we have already spoken (§ 325, 326), in the Article of Cobalt. Whence it is evident, that the Ore of Bismuth may without Impropriety be called Cobalt of Bismuth: The more, because you will find in any Ore of Bismuth the same Principles as in Cobalt, only in a different Proportion.

Scholion. *It will not be improper, here to give an Account of the making of Zafre and Smalt, which Kunkel has first described with Clearness, in his Ars Vitriaria. For Instance, Cobalt leaves after the Sublimation, and Bismuth after the Fusion, a Caput Mortuum, which is in a special Manner called by the Germans Bismuth-Craupen, when there remains something of the Ore of Bismuth. It contains an Earth, which being melted together with the Ingredients of Glass, gives Glass an azure Colour. It is first beaten into Powder, then sifted through a fine Sieve, then mixt, by grinding and piercing, with a very fine Powder, made either of Sand or of white Flints, and which is even double in Quantity, with regard to the foregoing. If you sprinkle with Water this compound Powder, which is called Zafre, the whole will then make a Stone of a middling Consistence: But as this sprinkling is always done before the Zafre is sold, some have taken it on this Account, for a native Mineral.*

But if you grind and mix this Zafre together with a sufficient Quantity, for Instance, once and a half as much of

† In the Museum of the Royal Society are Pieces of Bismuth-Ore, sent from Cornwall under various mistaken Names, but so very rich of Bismuth, that, by only holding a Piece with a Pair of Tongs against a clear Fire, the melting Bismuth will run down in form of melted Tin or Solder, almost as soon and as easy as Cheese will drop in roasting.

Pot-Ashes, and then melt it in a great Fire; this produces a Glass, whose Colour is almost black; which however, if thrown into Water immediately after it is put in Fusion, and then ground and sifted, produces the finest blue Powder, which is called Smalt †.

If the self-same Zafre, or the Smalt made of it, is mixt with a hundred Times as much or more, of crystalline pounded Glass, or with anyother of the Ingredients out of which white Glasses are made; then the Colour which appeared so very black in the melted Smalt alone, turns into the most beautiful blue saphirine Colour: whence some pretend, that the Word Zafre has had its original.

Of ZINK, and its Ore.

408. Zink, is called in German *Contrafait Spiauer*: whether it is or ever was found native, in the same Form mentioned (§ 14), is a Secret to me: nor is there any known kind of Ore, out of which this Semi-Metal may be melted in the same Manner as the other Metals and Semi-Metals are melted out of theirs.

409. Therefore, all the Zink that is prepared in Germany, especially at Goslar, is obtained by Sublimation, not by Eliquation, and not got out of any singular Ore, but out of such an intricate and confused Mixture of different Ores, that several other Metals and Semi-Metals may be separated at the same Time from it. Iron, Lead, and Copper are also contained in it in great Plenty: and are almost all involved in Sulphur and Arsenick.

410. There are no peculiar Sublimations made for the extracting of Zink, but, by a Sort of secondary Operation; it is collected during the Eliquation of the other Metals, especially of Lead.

411. It is proper here to explain the Manner, in which the Sublimation of Zink (§ 409) is made, because there is hardly any accurate Description of it to

† See the Note (§ 325.)

be found in Authors. The Ores that yield Zink, are by a long and several Times repeated Roasting, freed from Sulphur, and in a Manner from Arsenick by the same Operation. When laid into Strata (§ 240.) with Coals, they next are put into prismatical, quadrangular Furnaces, the Height of which is several Times greater than their Breadth and Length. Three of the Sides of every such Furnace are so many thick Walls; but the fourth, which is in Front, is shut up close with Plates, cut out of a kind of Stone easy to be cleft, that will bear a strong Fire, and hardly above one Inch and a half thick. There is another Plate made of the same Stone, applied within to the inferior Border of the lowermost of these Plates, and placed in such Manner, that rising up obliquely and inwardly from the said Border, it makes a Channel declining towards either Side of the Furnace, ending in a Hole left in that Part of the Furnace, and designed to carry thence into this Hole, whatever falls into its Cavity. If then the Ores (§ 409.) melt in a great Fire, excited with Bellows, placed below the back-Part of the Furnaces; at the same Time the Zink, which is altogether volatile, applies itself Drop by Drop to the just described thin, foremost, and always le's hot Wall of the Furnace, and very much likewise to the Joints of the stony Plates of which it is made; because these Joints from Chinks and Furrows that are inequal. In this Case, if the said foremost Wall of the Furnace is struck lightly many times over, during the Fusion, the Zink flowing down Drop by Drop, falls into the hollow Channel just described, and is, by its Declivity, determined to run towards the small Hole which is at the End of this Channel, and thence to fall and gather into a small Vessel put under it. Nevertheless, a very great Part of the Zink is burnt and dissipated during this Operation; which is also evidenced *a Priori*, by the easy Combustibility of Zink in a much milder Fire; and chiefly by the beautiful green Colour of the Flame, that rushes out of the Furnaces at that Time, and by
the

the white, thick Smoak that comes out along with it. For you always see, and with no small Pleasure too, a Flame of this Kind, especially towards the End of the Operation. Therefore, out of the vast Quantity of Ores, which is at several Times put into any one of the Furnaces, within the Space of 18 Hours, and which is more than sixty hundred Weight, not reckoning the additional Ingredients, you will hardly obtain three, four, or at most five Pounds of Zink.

Coroll. It is then plain from what was said (§ 408 and 411.) how difficult it is, to pass any certain Judgment upon the Ore of Zink, as it proceeds from so great a Confusion of Ores and Minerals, and in so singular a Manner.

412. However, there are besides the Matrixs of Zink hitherto mentioned, that are found at Goslar, some others which may be called *Zink Ores*. To this Class belongs especially the *Lapis Calaminaris*, or Calamine, in German *Balmey* and also *native Cadmia* to distinguish it from that which is called (§ 89.) *Furnace-cadmia*. This is of a Figure altogether irregular, sometimes spongy, and now and then solid. It is yellow, Gold Colour, red, sometimes grey, or even of a Colour which is a Mixture of all the foregoing: As for the rest, it is not very heavy, nor hard: when roughly broken in Pieces, and thrown into a violent Fire, it immediately renders the Flame of the Colour mentioned (§ 14), and exhales a white, thick, copious Smoak, which however has not the Smell of Sulphur or of Arsenick, but a sweeter Smell peculiar to it, and vastly astringent, and which condensates into very light Flowers, which are at first bluish, and then of a greyish White. Only take care not to make this Experiment with such Bits of the *Lapis Calaminaris*, as are accompanied with the yellow sulphureous Pyrites (§ 316), or with the white Arsenical one (§ 323), or also with Lead-Ore (§ 373): for they now and then happen to be associated with this kind of Stone. Besides, the volatile Part just

described, there is a great Deal of Iron in the Calamine, and moreover no inconsiderable Quantity of unmetallick Earth.

413. You can never, by the only Force of Fire, or by the help of the common reducing Fluxes, produce any Zink out of this Stone (§ 412). However, the Agreeableness of the Flowers of the said Stone (§ 412.) with those of Zink; the changing of the red Colour of Copper into the yellow Gold Colour, which Alteration is effected both by the Calamine, and by Zink † (§ 88); and finally, the Production of Zink itself out of the *Lapis Calaminaris*, to be obtained by several manual Operations, require that we should class it among Zink-Ores: of this more particularly, when we come to the Operations.

414. Some Authors have given us several Observations, concerning the Ores that are proper to Zink, and out of which it may be melted, as other Metals are out of their Ores. But though I would not invalidate their Authority; there are however many Reasons, why I cannot believe, that the Ores to which they ascribe the Name of Zink, are such in reality. For, 1. Zink is confounded with Bismuth by several Authors: so that both these Names are looked upon as synonymous; while there is nevertheless a very great Difference between these two Bodies, as it clearly appears from the Characteristicks of each, exhibited (§ 14, 15), and which are easily discerned by the Senses; not to mention greater Differences, between them, which are manifested by Chemical Operations. It will be enough, for Instance, to mention one single Author, even *G. L. de Lobneys*, a Man indeed of no little Rank among Metallurgists, and who nevertheless, speaking of the Manner in which the Zink of *Goslar* is got out of its Ore, says; *Hoc Zinnum*.

† Out of Zink and Copper may be made as fine a beautiful yellow Metal, resembling Gold to the Eye, as the famous Bath-metal so long in vogue, or a more modern Metal at present, in great Use for Cane-heads, Buckles, and other Toys.

five Bismuthum auide ab alchemistis desideratur. See his *Nachricht vom Bergwerck*, p. 83. b. 2. Authors have either entirely neglected the Description of the Zink they speak of; or, if they have said a few Words about its Characteristicks, the very same Properties belong likewise exactly to Bismuth. Besides, Bismuth-Ores are rather found in many of those Places, which Authors say contain Zink in Plenty, than Zink-Ores: for Instance, in *England*, the Zink of which Country is very much talked of; though at the same Time it seems hardly to exist at all there: what confirms me more in this Opinion, is a clear Passage in *Webster's Metallographia*, p. 339; wherein this Author owns, that he has to no Purpose looked out every where for Zink-Ores, especially in *England* *.

415. The *Dutch* bring to *Europe* in their *East India* Ships, a great Quantity of Zink, which is a little more blue than the German Zink, and in every Respect more tenacious †. But we know nothing certain, either of the Country where the Ore that contains this Zink is digged out, or, and much less of the Manner in which Zink is obtained out of it: For they say no European is granted the Liberty of entering into those Countries.

Of VITRIOL, and vitriolick Minerals.

416. When a Metal or a Semi-Metal is dissolved by the acid Salt of Sulphur, in such Manner that both may appear under the Form of Salt, when joined together; such a Concrete is strictly called *Vitriol*.

* These are his Words. *I know not, what use is made of this Spelter, but only that the Brasiers do mix it with Copper, and thereof make their Cement or Solder: for from them we have it, and that at very dear Rates. The Ore of it I have not seen, nor as yet could procure; and I should be very glad to hear that any of it could be obtained, or any of it found in England.*

† It is known in *England* by the Name of *Tutinag*.

417. We have hitherto found but two Metals in the mineral Kingdom, that are naturally dissolved by this Acid of Sulphur, *viz.* Iron and Copper. Therefore, they reckon only two native Vitriols, *viz.* that of Iron, and that of Copper. The former, which is green, semi-diaphanous, consisting of rhomboidal Crystals, and of a sweet, astringent, styptick Taste, melts first in the Fire, and casts out an aqueous Vapour, and then dries up, and turns into a grey Powder, which, by increasing the Fire, at last becomes of a reddish Colour; while at the same Time an acid suffocating (§ 22.) Vapour is expelled out of it. But the Vitriol of Copper, when artfully separated from the foregoing, and rendered pure, is blue, less transparent and aqueous, more ponderous, not melting so easily in the Fire, of a very unpleasant, caustick Taste; and otherwise not very different from the other. Both these Vitriols, dissolved in Water, impart to it their own Colours.

418. These two Vitriols most commonly are found joined together; just as the two Metals out of which they are extracted, when the said Metals have been dissolved by the Acid of Sulphur, are hardly ever found solitary, but are most commonly mixt with each other in many different Proportions. In the mean Time, the Vitriol of Iron is very predominant in these concrete Bodies. It is an easy Matter to find out, whether there is any Copper in any Vitriol, if you put a well polished Plate of Iron into the Solution of Vitriol: for then there is always some Copper driven out, which applies itself immediately to the Surface of the Plate, under the Form of a very fine red Powder. But, whether, or in what subterraneous Places, the Vitriol of Copper may be found as pure as the blue Vitriol we buy, I indeed know not. That Vitriol seems rather to be artificial, which is sold under the Name of *Roman Vitriol*, *Cyprian Vitriol*, &c.

419. Native Vitriol is inherent and dissolved in many Waters: for Water must always concur, to
cause

cause the Acid of Sulphur, to assume the Form of Vitriol together with the Metal; because no Salt can exert its saline Virtue, unless it be dissolved by Fire, or by Water. Besides, the crystalline Form and Transparency of Vitriols, can never be procured without the Intervention of Water. But the vitriolick Salts constitute many Waters, called on this Account medicinal Waters, as are the *Pyrmont* Waters, and several others. Wherefore, you may also *ex tempore* find out, whether such Waters contain Vitriol, by pouring some Water upon a boiled rough Vegetable, for Instance upon Tea, Galls, the Herb Tormentil, Snake-weed, &c. for this Mixture turns immediately into a black opaque Ink, if there is any Vitriol of Iron mixt with it. But whether the Water contains Vitriol of Copper, will appear, if after having put pieces of Iron into it, they are successively consumed, and the Copper on the contrary precipitated, which is of course. Nay, if there is a great Quantity of Vitriol of Copper inherent in the Waters, the Copper, on this Account, being abundantly expelled by the said Pieces of Iron, at last grows solid, and appears rough and blistered on the Outside, and seems to consist within of a great Number of parallel Filaments, and to be more easy to break in the Direction of the said Filaments, being otherwise of a ductil Nature. In this Case, such precipitated Copper is called by the Germans **Coement-Kupfer**; and the Waters which are impregnated with an Abundance of Vitriol of Copper, are called **Coement-Wasser**. This occasions the Custom among the Germans, of calling all vitriolick Waters by the Name of **Kupfer-Wassers**; though they contain a very great Quantity of Iron, and very little Copper.

420. Pure Vitriol is also found here and there in the Mines, in a solid various Form. It is sometimes congealed like Water frozen, and is then called *Vitriolum Stalacticum* (§ 357), which is of a green Colour, mixt more or less with blue, indicating the Presence of Copper. It is compact, and is,
neither

neither within nor without, of the Figure it assumes when crystalized according to Art. They have at Goslar native white Vitriol of this Kind, which being dissolved in Water, and inspissated again, preserves its white Colour, and is found no where else, as I can remember. It contains Copper and Iron, and something besides, that is not metallick; the Nature of which is not yet thoroughly known. So that nobody, that I know, has been hitherto able to imitate it so well, as that the artificial one might not be distinguished from the natural. There are besides several Germinations, and vitriolick Efflorescencies within the Mines; and even in the Surface itself of the Earth, they are sometimes of a dense Nature, sometimes woolly; they may be found white, green, and bluish; an infinite Number of needless Names has been given them, which can have no other Derivation, but the infinite Variety both of Figures and Colours, resulting from a fortuitous Mixture of heterogeneous Matters, and of course deserve to be overlooked.

421. The Ink-Stones, *Lapides atramentarii*, called in German *Atrament-Stein*, are mineral Concretes, in which the Vitriol already perfect (§ 417.) lies hidden, but confounded sometimes with many other Earths and Minerals. Whence it again easily appears, that the Diversity of these Stones is infinite, with regard to their Weight, Hardness, Colour, &c. and cannot be determined with Certainty. It likewise follows hence, that the various Names, taken from these accidental Differences, are altogether useless, because all the Vitriols extracted out of any one of these Bodies, and purified, are entirely the same as that already (§ 417.) mentioned. There are four Species of these Stones chiefly reckoned, with regard to the Difference of Colours: *viz.* the black, the grey, the yellow, and the red Ink-Stone. Among these, the yellow is very remarkable, by its most beautiful but very decaying Colour, by its soft Consistence, and by the Quantity of Vitriol it contains. But the others cannot

cannot always be distinguished so easily; nay, they commonly enough resemble the Ores of other Metals; and indeed sometimes carry Particles of several Ores, that have grown together with them. Nevertheless, as they contain Vitriol already perfect, the vitriolick Taste is an infallible Characteristick of them all; so that they immediately manifest themselves (§ 417.) to the very first Taster that brings them to his Lips.

422. We must also here speak of the sulphureous Pyrites of Iron and Copper (§ 316, 347, 369). They certainly have in them all the Principles, that may give Birth to Vitriol (§ 417), viz. Copper, Iron, and the Acid of Sulphur. For some of the Pyrites of Iron, being exposed in the Air, split of their own Accord, and turn in part into Vitriol. Of this kind are the pure, merely sulphureous (§ 316.) Pyrites of Iron: But the Pyrites of Copper, even of arsenical (§ 369, 323.) Copper, do hardly so. The others must be previously roasted, and exposed in the Air for some Weeks or Months, to produce Vitriol. Of this Kind are the Pyrites of Iron and Copper, and those which have something arsenical in them, together with Sulphur, as is observed by the illustrious *Henckel*. Nevertheless, you must make a great many Experiments as to this; for there are some Pyrites of Iron, which being exposed to the Air, will not turn into Vitriol of their own Accord; although they do not contain more Copper or Arsenick, than some others, which turn into Vitriol in a few Days.

423. There are also many Calamine-Stones (§ 412), which will produce Vitriol, after a previous Roasting; though they are not of the Pyrites kind, and though you cannot demonstrate by the Success of any Experiments, that they contain as much Acid, as is necessary for the Generation of the Vitriol that is got out of them.

Scholion. *He that is willing to enquire into the meaning of these obscure Words, Sory, Misy, Chalcitis, Melenteria, &c. to know the Things they signified among the*

the Ancients, will perhaps here find the Place to which they belong.

Of ALLOM, and the Minerals out of which it is extracted.

424. Allom (O) is a Salt of a white or a light reddish Colour, and of a sweet styptick Taste. When dissolved in Water, and duly inspissated and grown cold, it forms semi-transparent octoedral Crystals, which first melt, boil, and foam in the Fire, and emit Phlegm in great Plenty, and then turn into a light, spongy, and very white Mass: But the Fire being increased, they at last give the same acid Spirit as Vitriol (§ 417), or burning Sulphur (§ 312.) do, there remaining a light kind of white Earth, nearly of the Nature of (§ 31, 2.) Marl.

425. Allom (§ 424.) is produced, either out of a black, shining, bituminous Mineral, easy to be cleft; hence of the Nature of (§ 319.) Sea-Coals, very uniform, but light, sometimes fibrous, and resembling Wood; or out of a soft bituminous Lump. These Lumps are inflammable, and, when gathered into Heaps, they of themselves grow hot, and take Fire, sending forth mean while a foetid, bituminous, strong Odour, and leaving after they are burnt a kind of spongy Earth, that has a little Taste. But when they do not take Fire, but only grow warm, and cleave; then they become very fruitful of Allom: therefore, you must prevent their taking Fire, by pouring a little Water upon them; because their happening to be inflamed renders the Masses unfruitful.

426. But the other Minerals out of which Allom is produced, are not bituminous, nor of Course inflammable. To this Class belong some Concretes, resembling common Clay, that cleave easily as likewise the Calamine mentioned (§ 412). However the latter, as well as the foregoing (§ 425.) bituminous Species, requires to be gently roasted previously in an open Fire, to produce Allom.

427. It

427. It often happens, that, while the Pyrites is preparing for the Generation of Vitriol (§ 422.) a considerable Quantity of Allom comes along together with the Vitriol; which may commonly be observed in Ink-Stones (§ 421); as these often deposite Vitriol and Allom together, by pouring Water upon them; which however is not common to them all.

428. New, pure, aluminous Minerals, which are not of the Pyrite kind, when chemically examined, yield but very little of the Acid of Allom, or none at all, or at least not a Quantity answering to that of the Allom gotten out of them, after they have been a while exposed to the Air. Nor can one see the Earth contained in these Minerals, which remains after the burning (§ 424.) of the Allom. The crude Calamine (§ 412, 423.) likewise when it is pure, not mixt with any Pyrites, nor accompanied with any steel-grained Lead-Ore, appears to contain these Principles in a much less Quantity. Nor indeed is there any metallick or unmetallick Earth in this Stone, like the *Caput Mortuum* of (§ 424.) Allom. But if we must believe that it contains Acid in reality; it is hardly conceivable, how it can lie so much concealed therein. Now we leave it to the Judgment and Experience of every body, to determine whether the Acid of Allom, carried by the Air, is thus deposited in the Matrix of the Allom, according to the Opinion of the illustrious *F. Hoffman*^a, or if the new Generation of the two Principles of Allom, that is of the terrestrial and the saline Acids (§ 424.) is made by Means of the Air, or of the Fire, or of both together, as is thought by *Henckel*^b; but, as it is hardly possible to have an accurate Notion of this Matter, before we know the Operations, we shall have Occasion to treat of these Things more at large, when we come to our practical Part.

^a Observ. Physico-Chemic. L. 111. Obs. 8. pag. 275.

^b Pyritologia, pag. 756.

Of COMMON SALT, and the Methods by which it is obtained.

429. There are in several Countries Mines easily come at, out of which the purest, native, common Salt (§ 20.) is gotten in a solid Form: it is called *Sal Gem*, or *Rock-Salt*. This Salt is perfectly pure, white, half-transparent, and different from the other common Salt, by its large, compact, and apparently homogeneous Crystals, which larger Crystals produced by Art, are a Collection of many smaller Ones: It is much more permanent in the common Air, nor does it contract a Moisture so soon as the vulgar Kind of Salt. But these so very pure Pieces of *Sal Gem* are not found in so great Plenty; but, as one may easily guess, they are now and then infected with other compound Minerals that mix with them. But, when these foreign Bodies are mixt with the Salt in large Quantities, it is freed of them, by dissolving it in Water, letting it settle, and then straining it; and finally, by evaporating the Brine (for that is the Name of the Solution of it in Water), the Salt is again restored to its solid Form. But then it is no longer styled *Sal Gem* *.

430. The whole Ocean, and the several mediterranean Seas, (or larger Lakes) are full of common Salt: Nevertheless, the Waters of them all are not equally saturated with it. Some, in one Pound of Water, will have above an Ounce of Salt dissolved; and some others hardly half an Ounce, and even less. Above all, the Seas that lie under and about the torrid Zone, are more full of Salt, than the Icy Seas towards the North. The Salt, which is fetched out of them, either by the bare Evaporation in the Sun

* But Sea-Salt, or the common Salt used in domestick Affairs.

and the dry Air †, or by being inspissated on a Kitchen Fire, is called *Marine* or *Sea-Salt* ‡.

431. Finally, there are many Springs, the Waters of which are impregnated with common Salt, out of which it is obtained in the manner mentioned (§ 430): They call it *Sal fontium*.

432. These three Species of common Salt (§ 429—431.) do not differ upon any other Account than 1. That of the Place where they are found, and from which they have all their peculiar Names. 2. Of their Purity; for the heterogeneous Bodies mixt with them, spoil the Colour and outward Look of the Salt. This is the Reason why some Brines drop their Salt easily, and without any Addition, by bare Evaporation, and some others with great Difficulty, or not at all, unless you add clarifying Ingredients. Mean while, as such foreign Bodies are not essential, but merely accidental to common Salt; they no way constitute a real Difference; for any common Salt, provided it be well purified, appears always one and the same ||, after many Examinations. You may read on these Subjects *F. Hoffm. Obs. Phys. Chemic. Lib. II. Obs. XVI. G. Agric. de Re Metallica, Lib. XI. P. Snellius de Sale communi*, and others.

433. Salt Ammoniac may be referred to this Class, as being a semi-volatile kind of common Salt. They

† Is called in English *Bay-Salt*, the finest of which comes from the Rocks on the Coasts of *Sicily*, and great Plenty of it is prepared in the Salt-Ponds near *la Rochelle* in *France*.

‡ Great Quantities of which is made in *England* by dissolving Rock Salt in Sea-Water, and evaporating the Water till it bears an Egg, which being set to cool, the Salt shoots in it in the Form we have it for Use; the Crystals being first dried. The Brine which is poured off, is of a very bitter Taste, and is therefore called *Bittern*; this again, boiled down, and set to crystalize, gives a bitter tasted Salt so much in use of late for Purging, and is commonly sold under the Name of *Epsom Salt*, from its Resemblance to the Salt prepared out of those medicinal Waters.

|| *Bay-Salt* is the most impure, having more earthy Particles in it. Concerning the best Method of making Salt or Sea-Water fresh and wholesome to drink, see those curious Experiments in a Book entituled *Philosophical Experiments, &c.* by *Stephen Hales, D. D.* *F. R. S. Lond.* 1739, in 8^{vo}.

say, that this fossil Salt is found native about the Vulcano's, or Mountains that vomit Fire, as also in the sandy, dry, burning Places that are about and under the torrid Zone; and that it is likewise evaporated from the Crevices of the Rocks in *Persia*. But the vulgar Salt Ammoniac which is sold, is all artificial, and is produced out of the Bodies, which actually, and in reality contain common Salt, or its Acid, and the volatile alkaline Salt. Because these are two Principles, of which every Kind of Salt Ammoniac consists, and into which it may be resolved by Art; therefore the Urine of Animals, especially of those that use common Salt; the Soot of many inflammable Bodies, &c. yield this Salt. They say that the Salt which is brought us from *Egypt*, which is the most common, is prepared by Sublimation, either out of the Soot of burnt Dung * of Animals alone, or out of this very Soot mixt again with common Salt, and with the Urine of Animals. See *Acta Parisina*, and *Boerhaave's Elem. Chem. T. II. Proc. CII.* That which is brought from the *East-Indies*, not in flat convex Loaves, but in conical Ones, like sugar-Loaves, is rare, and the Manner in which it is made, unknown. It is enough for us to be certain, that every true Salt Ammoniac may be resolved into the two *Principia* before mentioned, and that likewise out of these, Salt may be made in every Respect perfectly like native or artificial Salt.

Of BORACE, and its Origine.

434. We have already (§ 131.) treated of Borace, as of a Menstruum. It is otherwise, though less usually, called *Chrysocolle*, that is, *Gold-Sodder*: tho' at the same Time, this Name is much properer to it, than to the green Oker (§ 366.) of Copper; which, though called by the same Name, yet is altogether

* Especially the Dung of Pidgeons, and the Urine of Camels.

different from Borax, and on this Account ought not by any Means to be confounded with it. But the vulgar Borax we buy, which they call (refined) when purified, appears to be in every Respect adulterated. That which is crude and called fat Borax, or Tincal, and is brought us from the East, especially the *East-Indies*, is certainly very different from that which is called refined Borax. But we know not yet, what additional Ingredients they make Use of for the purifying, or rather the adulterating of it: for they look upon it as a Secret. Nor do the Purifiers of Borax willingly admit any Body into their Laboratories, which are chiefly at *Amsterdam* and *Venice*.

435. We observe a Figure constant enough in crude Borax or Tincal (§ 434): It consists of prismatical, hexaëdral, nitrous Crystals, truncated on every Side, and sufficiently thick; nevertheless, not so long or regular, as are the nitrous, nor so closely joined, as is seen in other Salts, but more simple and solitary, of a bluish Colour, pretty hard, ponderous, very difficult to be dissolved in Water, of a sweetish Taste at first, and then having an alkaline after-Taste; easily melting in the Fire, and not so apt to rise into a Foam, as that called refined Borax.

436. We have not hitherto heard any certain Relation, concerning the Manner in which Borax is primitively obtained; whether it is found native in the Earth, such as it was described (§ 435); or washed out of a certain Matrix, like Nitre, and then by Crystallisation reduced to the already-mentioned Figure: which indeed appears to be more probable than the former.

Of NITRE, and its Matrix and Generation.

437. Nitre, or Salt-petre (§ 21), is always ingendered on the Surface of the Earth; it is never gotten out of the Mines; for if you dig into the Earth above one Foot deep, you hardly find any more Ma-

trix impregnated with Nitre: nor is it even found at so great a Depth, unless it has been by Waters washed off from its Matrix, and thus carried lower down together with the said Waters: Which, nevertheless, happens in this only Case, when the Soil under it is chopped, or of a stony, porous Nature; because the Water itself can hardly penetrate above two Foot deep into a great many Earths.

438. The chief Matrix of Nitre are calcareous, clayey, loomy Earths, and a kind of moist Earth which has all its Origine from vegetable and animal Bodies, destroyed by the Vicissitudes of the Air. If there join to them Ashes of burnt Vegetables, especially of those out of which a great Deal of fixt alkaline Salt is fetched by Fire; if the said Ashes are not quite deprived of their Salt by boiling: and if the fat, oily, rotting, or already rotten Parts of the said animal and vegetable Bodies are added; then a perfect Generation of Nitre is performed in the said Matrix: for there is never any Nitre produced in an Earth quite destitute of all Phlogiston: you are only to take care, heedlessly, not to mistake for Nitre, the calcareous stalactical Efflorescencies, that are found against Bridges and Walls.

439. Nor is it very important, where the already mentioned (§ 438.) Matrix of Nitre be placed: for there never was yet any Place found unfit for the Generation of Nitre, provided the abovesaid Bodies (§ 438.) do concur to it. However, it is requisite that the Place be quite in the open Air, and temperate as to Moisture and Dryness: for an excessive Humidity washes off the Nitre already conceived, and when a diluting Moisture is altogether deficient, the saline Matters hardly act one upon another. In the mean Time, it is certain that Heat and Cold are here neither much useful nor noxious, unless both be very excessive. However, the greatest Heat of the Sun is to be avoided.

Coroll. It is plain, from what has (§ 437—439.) already been said, that Nitre may be ingendered in

all Countries, and that some Places are more proper, some less, for erecting Salt-petre Works. It is likewise plain, that most probably the Air is either the instrumental or the material Cause, or perhaps both together, of the Generation of Nitre, or at least carries it in its Bosom. For you infallibly hinder the Generation of Nitre by obstructing the Passage of the Air. The Reason is likewise plain, why the East and North-Winds are so beneficial to the Places where Nitre grows, in those Regions, and in the Climates between them, especially during the Spring and the Autumn; while, on the contrary, the West and South-Winds are quite unproductive of it. For it has been observed, that, in the Spring and Autumn-time, the East and North-Winds are neither too moist nor too dry, especially during the Night; and that, being too drying in Winter and Summer-time, they parch every thing. But the South and Westerly Winds, being stormy, and bringing Rains along with them, are there very hurtful: however, it is well worth our Inquiries, nor have we hitherto found out by Experiments sufficiently accurate, whether these Winds are detrimental to the nitrous Matter, merely by an excessive Moisture, or (supposing this to be prevented) are hurtful to it upon some other Account.

440. Whoever would be pleased to make Experiments in these Matters, and to do it easily, and with little *Apparatus*, might procure himself a Nitre-house, by exposing in a proper Place (§ 439.) the Matter in which it is (§ 438.) ingendered. An Example will clear this Point. Chuse any Place quite open to the Air: However, a Field or a Garden will be best. Upon the Area of it, which must be eight Foot long, and as much broad and deep, build a small Hut of Mud, having its Top thatched with Straw, and sloping, to shelter it from the falling Rains: Let the Height of it from the Ground be such, that a Man standing upright may walk under the Roof. Let a Door be made, through which the Artificer may

get into the said Hut, and that may be opened and shut. Besides, leave here and there in the Walls small Windows with small Shutters to them; that you may at Pleasure admit or keep off the Air from it. Against the right, left, and hinder-Walls of this Hut within, contrive square Partitions two Foot long, as much broad, and one Foot deep, divided with wooden-Boards one Inch and a half thick. Fill them with many different Compositions of the Things mentioned (§ 438). By this Means, you will be able to make several Experiments upon this Matter. If you make a Paste with Mortar *, Ashes, or moist Earth, pouring Urine upon it, and fill one of your Partitions therewith; if besides, you water it a second Time with Urine, when dry, and beat it well with a Stick, after every such Watering; you will find, in a short Time, that Nitre has soon been ingendered in these filthy Matters: For, unless a very severe cold Season happens, a Pound of such a Mass will, in a Month or two, contain about two Ounces of Nitre. Now the Method of finding out whether there is any Nitre in a Matrix, and what Quantity of it lies hidden therein, shall be shewn in the second Volume of this Work, when we come to the Operations †.

441. Besides, the Ores and compound Minerals hitherto (§ 305—440.) described, there are some, whose Nature and Principles are not yet sufficiently known; so that they cannot have any certain and determined Class assigned them. Nevertheless, it is beyond all doubt, that they no way belong to the Classes of such as yield precious Metals. For Metallurgists and Assayers, in all the Trials they make about Minerals unknown to them, have almost no other View, but that of finding out, whether Gold, Silver, Copper, &c. may be extracted out of them

* Or the Rubbish of old Stone-buildings, especially where the Cement hath been Stone-Mortar.

† Salt-petre is brought to us in the greatest Plenty from the *East-Indies*, but we are not certain whether it may not be found native in these Countries.

with

with Benefit: and when the Negative is the Case, they most commonly forbear from any further Inquiry. For this Reason, there has been hardly any Mineral hitherto found, that went not through a strict Trial in the same View. There are even a great many compound Minerals, among such as have been ascribed to certain Classes, which are known only in part, and not at all thoroughly. Of this Kind are, for Instance, the Hæmitrites or Blood-stone (§ 349). The filamentous striated Iron-Ore (§ 353). The shining, scaly, striated Iron-Ore (§ 352). The native Manganese (§ 351) &c. the Principles of which are not known, except that Part of them only, that turns into Iron, For this Reason, the Iron, which most commonly constitutes the major Part of the Pyrites, has long been a Secret to the Ancients, who only regarded the Copper envelopped in it: whence, the many Names given to many Pyrites are almost all derived from Copper; till at last some of the Moderns, especially the ingenious Mr. *Henckel*, gave us a compleat Analysis of them in his Book cited (§ 399) above.

442. Among the Minerals not yet examined (§ 441), that which chiefly deserves our Consideration is, the *Molybdæna*, or otherwise called *Cerussa nigra*, *Plumbum marinum*, in English *Wad* or *Black-Lead*, in German *Wasser-Bley*: it must not be confounded with the *Galæna*, or Steel-grained Lead-Ore (§ 373), which, though commonly called by the same Name, yet is altogether different from it*. The Black-Lead is a Mineral of a Lead Colour, consisting of small shining Scales, soft, so as to be easily scraped with a Knife. It is much heavier than the glimmer-Stones (§ 31. N° 7), of which it has almost the whole Texture: it feels much like Soap, and its rubbing

* Formerly, the almost only Mine for Black-Lead was in *Barrowdale*, near *Keswick* in *Cumberland*; but a very large rich Mine of it was since found out at *Tantiusquis* in *New-England* by the famous Governor *Winthrop*, at his first settling that Country. The aforesaid Mine is at this Day part of the Estate of his Grandson and Heir *John Winthrop*, Esq; it is found by the Curious to contain a great Deal of Silver.

against solid Bodies, renders them slippery: whence, Workmen rub their Presses, and other Tools, with Black-Lead instead of Soap; partly to facilitate Motion, and partly to cover and keep off Rust, by such a Lay of a shining Black Colour. It is likewise commonly used for Writing Pencils. It hardly suffers any Alteration in the strongest open Fire*; except that, being thus divided into very small Particles, it loses its Colour entirely, and becomes of a Consistence somewhat softer. We shall, when there is Occasion, in our second Part, at large mention this Mineral, and all the Particulars thereto belonging.

C H A P. V.

Of docimastical Operations.

443. **T**HOSE Actions which change the Objects of the Art, according to the Rules it prescribes, and by Means of the Instruments it employs, are called by Chemists *Operations*.

444. All the Changes just (§ 443.) mentioned are effected by Solution and Conjunction; so that whatever the Chemist does may, in general, be easily referred to these two Classes, nor can a third Species of Mutation be imagined, notwithstanding all some can say.

445. As the Art of Assaying consists in a well-made Separation of Minerals, especially of Metals, and in a Division from each other (§ 1.) of the several constituent Parts of them, that the Quantity and Quality of each in particular may be known; it is plain, that those Operations, which belong to the

* Black-Lead is of great Use for making Crucibles which bear the strongest Fire; the Powder of it mixt with Windsor-Loam makes a good Lute for coating Vessels over with; and it is of great Use among the Brass-Founders, who rub over the Insides of their Moulds with it.

general Class of Solution (§ 444) appertain strictly and primarily to this Place; and that the others, which are performed by the Assayer, are only secondary or auxiliary Operations.

446. As therefore Conjunctions are to be considered (§ 445.) here as only secondary; one may easily apprehend, that the docimastical Operations cannot be divided in general into Solutions and Conjunctions, as chemical Operations are. Nay, any Operation performed by a Chemist or an Assayer, commonly has the Effect of both the Solution and the Conjunction; so that no Solution can ever be performed without a new Conjunction, nor any Conjunction without a Solution. For Instance, while heterogeneous Bodies are separated from Gold and Silver by Scorification, do not the Particles of Gold and Silver melt together into a greater Bulk? Likewise, do not the Bodies separated, either of their own Accord, or with an Addition of some scorifying Body, melt together into Glass, and thus join again in another Manner? It will then be very wisely done, always to be attentive to either of these Effects in any Operation whatsoever, and to derive the Differences and Denominations of the Operations from the principal of the said Effects, and from the Diversity of the Apparatus of the Instruments (Chap. II. and III.), by which the Changes to be effected are made in the Objects (Chap. I. and IV.) of the Art.

447. But there is hardly any chemical Operation, which is not sometimes necessary to be performed in the Art of Assaying. There are many, on the contrary, which are peculiar to Assaying alone. Therefore, we shall here give a general View of those which belong properly to it, or of those which, tho' taken from Chemistry at large, are nevertheless very frequently used by Assayers; and shall then add short Descriptions of each of them in particular, derived from their primary Differences, their Effects, and the Methods used in performing them; that any Novice in this Art may thus be easily led to the Practice,

when we shall attempt to propose, in a more exact and clear Manner, special Observations upon every individual Operation.

448. Every primary docimastical Operation may, on Account of its Effect, be called Solution (§ 444); since, in every Operation, the *Menstrua*, among which I think the Air and Fire have a right to be classed, effect a true Solution, by interposing themselves between the Particles of the Objects to be changed.

Now a docimastical Solution is either	Dry	Fusion.	These may be called almost Universal; because they dissolve either the whole Mass, or at least by much the greater Part of the Subject in Hand.
		Vitrification.	
		Scorification.	
		Coppelling.	
		Reduction.	
		Amalgamation.	
	or	Sublimation.	We may call these Partial, as they all dissolve but one Part of the Subject in Hand.
		Cementation.	
		Roasting.	
		Calcination.	
Moist	Moist	Elutiation.	All these are Partial, and separate some Parts from the others.
		Edulcoration.	
		Quartation.	
		Moist Precipitation.	

449. When the Cohesion of a solid Body is so diminished by the Strength of the Fire, as that it may become fluid; then it is said to be in *Fusion*, or *melted*; and the Action itself, whereby this Effect is produced, is called *Fusion* or *Melting*, which is the most frequent among the Operations, that are proper to the Art of Assaying.

450. All the fixt Bodies hitherto known in the Nature of things may be brought into (§ 449.) *Fusion*; with this Difference however, that some melt of themselves in the Fire, and some not, unless you add to them a dissolving Body, that is, a *Flux* (§ 159—166.) There are also many among the volatile Bodies, that may

may be put in Fusion; but then they evaporate at the same Time.

451. When a Body melted (§ 449.) and grown cold becomes brittle, fixt, not dissoluble by Water, and melts again when exposed to the Fire; then it is called *Glass*; and the Operation which changes it in this Manner, is called *Vitrification*.

452. This *Vitrification* (§ 451.) is made use of by Metallurgists, to the End, that any Metal imprisoned in a solid Body may, on account of its Weight, descend and separate itself therefrom: and when the Metal itself assumes the Appearance of Glass, this Operation is technically called *Scorification*, in German *Uerschlackung*; and the Glass thus produced is called *Scoria*, in German *Schlacke*, in English *Dross*.

453. All fixed Bodies experience the same (§ 452.) Alteration, not totally excepting even Gold and Silver. There are also among the volatile Bodies, some that can be fixed, and which assume the Form of Glass again, by adding fixing Bodies to them.

Scholion. *They also call Scoria that saline Mass, which is produced by melting Metals and Ores, together with saline (§ 159—166) and reducing Fluxes: Nor ought, however, the Word Scoria to be then understood of all this Mass, but only of the vitrified Particles which adhere between the small Masses of the Salts, and which may be separated from them by a Dissolution in Water, and by Filtration.*

454. It is oftentimes proper, to make the *Scorification* (§ 352.) in a Vessel, that may absorb the Scoria itself, and retain the metallick Part. In this Case, it is called *Coppelling*. The Tests and Ash-Vessels mentioned (§ 168, 184, 185,) are designed for this Operation.

455. It is then self-evident, that a great Attenuation of the Scoria is requisite, that it may be able to pass through the Vessel. Nor is there any fitter Body for this Purpose than Lead, which, by its self undergoing a like Attenuation in the Fire, for this Reason

son disposes to the same Attenuation the other Bodies to be reduced into so subtile a Scoria.

456. There are Earths, which turn into Metal, by being intimately joined with an inflammable Principle: As Metals destroyed, and changed into Scoria or Ashes, are, by their Union with the same Matter, again restored to their metallick Form. This Operation is called *Reduction*.

457. All Metals and Semi-Metals may be reduced by this Method (§ 456), except Zink; which, being burnt to Ashes, admits of no Reduction. However, the Mixture of Gold and Silver was never radically dissolved by any Experiment hitherto known; wherefore, both these Metals need not be reduced by the Addition (§ 456.) of Phlogiston.

Coroll. Therefore, we must upon no Account refer to this Class, that Reduction by which the foreign Bodies, which do but conceal the metallick Form, are taken away. For Instance, Sulphur, Arsenick, Salts, &c.

458. The Observations to be made concerning Amalgamation, are already clearly hinted (§ 65--68), by what was said, when we treated of Mercury considered as a *Menstruum*.

459. When you are to join to a solid fixt Body, by Vapour, another that is volatile, the Vapours must be confined, lest they should be too easily dissipated in the Air; and the Body itself, which is to be penetrated, must be so placed, that the Vapours, very much agitated by the Fire, may as it were continually lick it *. The Manner of producing them has been already (§ 153.) explained, when we spoke of the menstrual Acids, which are to be applied in this Manner to Bodies, especially to Metals. Therefore, as these Things are very strictly joined to our Subject, they must of Course be repeated. But as they most commonly, in this Operation, lay first one Stratum of the dissolving Menstruum, reduced into Pow-

* Pass lightly over it.

der, and lightly moistened, and then another Stratum of the Body to be dissolved, upon the foregoing, and then again one Stratum of the Menstruum, and so on; Assayers, on this Account, have called this Operation Cementation, from the Analogy it has with the Works of Masons, when they make Walls.

460. However, there are other volatile Bodies besides acid Menstrua (§ 153.) that are joined in the same Manner (§ 459.) to fixt Bodies. For Instance, if such a Union cannot be made otherwise, than by Means of a strong and long-lasting Fire, that may dissipate the volatile Parts, then, by using a Cementation, the volatile Menstruum, to which you sometimes add some fixing Body, is rendered capable of sustaining a more violent Fire without evaporating, the free Action of the Air being stopped; and the Body itself, which is thus to be dissolved, being also attenuated, and more opened by the same Action of the Fire, is extremely well disposed to receive soon the volatile Menstruum. Thus Arsenick and Sulphur are conveniently united with Iron and Copper, and are easily corroded by a small Quantity of Acid, to which they resist more obstinately at other Times. Pure Iron, impregnated in this Manner with a great Quantity of Phlogiston, changes into Steel: for, the Action of the Air being stopped in this Operation, there are hardly any Bodies totally deprived of their Phlogiston by the Violence of the Fire. Char-coals are so least of any; because, though they were ever so minutely pulverized, they sustain for whole Days together the most violent Fire, in a Vessel which is but negligently covered, yet without being quite burnt to Ashes. But you will in vain expect the Effect desired, unless you use an exact Regimen of the Fire in these Operations.

461. There are some Bodies fixt of themselves, which may be rendered volatile, by adding volatile Bodies to them; so that they are, by different Degrees of Fire, resolved into dry Vapours. If Vapours thus produced collect together, when you oppose to them

them the cold Surface of a solid Body, that they may apply themselves to it, they are called Sublimates, and the Operation itself Sublimation: but they are chiefly and especially called Sublimates, when they form a solid Crust; and when they remain only under the Form of a fine Powder, they are called Flowers. The Sublimation is performed either in close Vessels (which Method is sufficiently explained in almost all the Writings of Chemists) or in an open Air, in which Case it is particularly called either Geber or Glauber's Sublimation. The latter is not indeed very common, but chiefly known among Metallurgists, in most of the Operations of which it is always made use of, while these Vapours apply themselves to the Walls and Funnels of Furnaces, and form the Scurfs and Flowers of the Furnaces (§ 89).

462. Sublimations are also made very well in close Vessels, by the first Method (§ 461); especially if your Glass-Vessels are capable of bearing the Fire: But there are many Fossils, which, though you use the violentest Fire, yet prove very refractory in close Vessels; so that you can do but very little, or even nothing at all with them. They, on the contrary, are, by the second Method called Geber's, presently resolved into abundant Vapours, in an open Fire, which must be blown very gently; as it is easy to experience in the Calamine, in the several Tutties, and the like. But that this Sublimation may be made perfectly, and the Flowers and Sublimates be exactly collected; a particular Apparatus is required, which may be very conveniently made in the following Manner: Instead of the Funnel (§ 239. N^o 4), put upon the Cover of the melting Furnace a large earthen Pot, not glazed within, of a round Figure, having at Bottom four or five Holes almost one Inch in diameter; in such manner, that the wide Orifice of the said Pot, inverted, may be received into the Mouth of the Cover, and the Bottom of it look upwards: then put upon this Pot in an inverted Situation

tion another of the same Kind, somewhat smaller, bored at Bottom in the same Manner as the first Pot which was set on the Cover: You may, if there is any Necessity, put upon this second Pot a third of the same Kind, and in the same Manner: Secure the Joints of the Cover and Pots on the outside, with Lute not very tenacious, that the Pots may be easily taken away and separated. The Pots, or other Vessels adapted to this Use, are commonly called *Aludeli*, or *Aludels*.

463. *Roasting*, called in German *Rosten*, is when volatile Bodies are separated from fixt ones by the combined Action of Fire and Air.

Coroll. Therefore this Operation agrees with the Sublimation (§ 461, 462), when a volatile Body, resolved in Vapours, is collected: because, after this Manner, Sulphur and Arsenick are extracted out of a great many Ores, and are refined.

464. But this Separation (§ 463.) is sometimes difficult enough; when, for Instance, the whole compound Body melts in almost the same Degree of Fire, that is necessary to cause a volatile Body to be dissipated in the Air. Therefore, it is chiefly necessary at that Time, 1. Previously to pound a little the Body to be roasted, that its Surface contiguous to the Air may be increased: (2.) A gentle Fire is required: (3.) A freer Access of the Air, which is the Vehicle of Vapours. (4.) When the Body roasting grows into large Clots, the Surface of it must be restored to its former Extent, by repeating the pounding. (5.) It is necessary that the Matter be spread wide, and never collected in a Heap. Bodies refractory in the Fire are more easily roasted: for you may constantly use a great Fire to them, nor need you repeat the Operation so often. However, you must always take Care, that, while the volatile Bodies are dissipating, they, at the same Time, do not take some thing from the fixt ones (§ 461). For this happens in a great many Cases, when you use too impetuous
a Fire

a Fire in the Beginning: to prevent this, they use sometimes to add some fixing Body; of which we shall speak in a more special Manner, in its proper Place.

465. Calcination differs little from roasting (§ 463, 464), as to the Manner of operating, but only with regard to the Aim of it. For in Calcination (though this be often attended with the Dissipation of the Volatiles) they only have Regard to the fine Cominuting of the Body. Therefore, by Means of this Operation, the Body falls presently into Dust, under the Fire itself of the Calcination, or at least splits easily, when a moist Air, or Water, comes afterwards in the Way; which happens in Lime-stones: Another Effect of Calcination is, that pliant Bodies assume a brittle Texture, as may be observed in Metals; and that the hardest Bodies may be split, and thus be afterwards more easily broken in Pieces: In which Case, it is often useful all of a sudden to pour cold Water upon calcined Bodies, even when they are hot to the utmost Degree. You have Instances of this in Flints, &c. Sometimes the Calcination is better performed by adding certain Helps. Thus Tin turns immediately to a Calx or to Ashes, by adding Lead to it, and by Means of a very strong Fire.

Coroll. Thence it is plain, that you must use in Calcination the same Manner of Operation, as in roasting (§ 464); because the former is performed by the Separation of the volatile Bodies: Nevertheless, it is not so in others.

Scholion. Both these Operations (§ 463, 465.) are most commonly confounded with each other, on account of their great Affinity; so that sometimes Calcination is called Roasting, & vice versa.

466. When any Part of a compound Body melting in the Fire, is separated from the Rest, in such Manner, that one Part sinks to the Bottom, and the other swims at Top, this Operation is called Precipitation,

tion by Fusion, in German *Trockene Scheidung* *. The inferior, heavier Part is called *Regulus*.

467. This Operation (§ 466.) almost always requires the Addition of such Ingredients, as may take away the mutual Connexion between the Parts to be separated; that is, the menstrual Virtue, by Means of which one keeps the other in a State of Dissolution. For Instance, the reguline Part (§ 16.) of Antimony, and mineral Sulphur (§ 138.) dissolve each other mutually, and constitute crude Antimony (§ 145); nor can they be separated from each other by Fire alone, without destroying the *Regulus*: But if you add Iron, Copper, Silver, &c. which are more thoroughly penetrated by Sulphur (§ 147. *Coroll.* 3), and are thus reduced to the State of Ore (§ 332); then the *Regulus* of Antimony is freed of the Sulphur; and sinks to the Bottom, as it is heavier than the additional Bodies then joined to the Sulphur. Such a Precipitation by Fusion happens in Vitrifications (§ 451), Scorifications (§ 452), and Coppellings (§ 454); while one Part turns into Glass or Dross, the other metallick Part, if there is any, keeping still its metallick Form, is collected at the Bottom of the spherical Vessel. Therefore, Silver and Gold, which are hardly subject to a perfect Vitrification, do constantly remain, and on this Account, though they were in ever so small a Quantity in a Coppelling, they shew themselves very clearly to the Eye, when the Scoria is absorbed; whereas so small a *Regulus* of these *Métals* would have been as it were buried and hidden under so great a Quantity of Scoria. Nor is Precipitation by Fusion less necessary, to obtain almost all the other Metals, which on this Account are called imperfect; unless, perhaps, you except a very small Quantity of native Metal, which, nevertheless, can hardly be called truly pure. Besides, they are all to be had either in

* That is *dry Parting*, or separating in a dry Manner, without any fluid Menstruum.

Form of Earth, or in that of a solid Ore: in the first Case, you make Glass by a bare Fusion: in the second, if the Sulphur and Arsenick, which, together with the metallick Part, do constitute an Ore, are scattered by the Roasting (§ 463.) the Ore destitute of the oily Phlogiston becomes Glass in a pure Fire; which Glass may be mixt with unmetallick Stones and Earths: but, by adding Phlogiston to it, this metallick Glass is reduced to its metallick Form, and, so long as it keeps under this Form, it cannot be united with the Glass of the other Species, but sinks to the Bottom of it; except only a very small Quantity of it, which is detained by the Clamminess of the Glass. Therefore the precipitating Body here is truly the Phlogiston. For any Body that takes away the Connexion, by the Removal of which a Precipitation is operated, is called precipitating, in German *Nieder-Schlag*.

468. When such is the Nature of the Ores, or of the metallick Mixtures, that, while one Part of them melts in the Fire, the other more refractory remains still solid, then the first, melted in a mild Fire, flows out of the Interstices of the other, and is thus separated. Which kind of Separation is called *Eliquation*, in German *Saigerung* *.

469. The Perfection of this Operation (§ 468.) requires, 1. the different Fusibility of the Parts that constitute the Mass. Lead, for Instance, melts into one Mass with Copper in a great Fire; whereas both cannot dissolve each other in a middling Fire: but if the Mass, composed of both Bodies confounded together, is afterwards exposed to a mild Fire on an inclined Plane, then the Lead alone melts, and the Copper, become brittle and spongy, remains in its solid Form. However, this Separation is not so perfectly made, but there remains a little Lead in the Copper, and a little Copper is carried away by the Lead: Wherefore, it is requisite, for this Experiment, that

* In English *Smelting*, or running down the Ore.

these Metals be not mixed together in too small Proportions: for if one thousandth Part of Lead was mixt with the Copper, & *vice versa*; the Eliquation desired would not succeed. 2. It is sometimes necessary to add Ingredients, that may either destroy the Force by which the several Parts cohere together, or even sometimes procure an easier Flux of the Matter: for the Mixtures of the other Metals, cannot without Additions be separated by Eliquation, as Copper and Lead were just said to be. For Instance, Gold, Silver, and Copper, confounded together, remain in the same State in any Degree of Fire. Therefore, to make the Eliquation of the Gold and Silver, out of such a Mixture, you must use the same Additions as in the (§ 467.) Precipitation by Fusion. Sulphur added in this Case, does indeed dispose the Copper to abandon the Gold and Silver: but if these two, as it most commonly happens, are mixt in a very small Quantity to a very considerable one of Copper; then you cannot yet obtain the Separation of them: For besides, that what we said before (§ 469.) concerning the Eliquation of Copper and Lead, is also true here; Sulphur does also render Copper fluid, by almost the same Degree of Fire, by which Gold and Silver are melted. Wherefore, a considerable Quantity of Lead must be added in this Case; that, by Help of it, the Gold and Silver may be dissolved in a gentle Fire; and thus the Copper be in a Manner washed out of them.

470. Both these (§ 466, 468.) Operations are of infinite use in Metallurgy: for, by Means of them, minute Portions of Gold and Silver, may, without any great Expence be separated from a large Mass of other Metals: which it has not hitherto been possible to effect with Profit, by any other Method. Nevertheless, these Operations have not been hitherto so far cultivated, as that Precipitation by Fusion, and Eliquation may succeed completely in all Mixtures of Metals: for which Reason, Metals that are of a

small Price, most commonly must be destroyed, to obtain a Separation.

471. We call Solutions moist, when a Body is distributed through the very minuteſt Particles of an aqueous, or in great part aqueous Fluid, in ſuch Manner that both may turn into a Fluid to Appearance homogeneous, which goes through all Filters without being detained in them, and the ſmalleſt Part of which contains in it a proportionable Quantity of both the diſſolvent and the diſſolved Body. The Solution of Gold in *Aqua Regis*; that of Silver in *Aqua Fortis*; and that of all Salts in plain Water, are ſo many ſuch moiſt Solutions.

472. That kind of moiſt Solution, by which Silver is ſeparated from Gold by *Aqua Fortis*, is called in Latin *Quartatio* *, and deſerves a particular Conſideration. If, for Inſtance, Silver and Gold are confounded in one Maſs, and the Gold is not leſs than one third Part of the whole Maſs with regard to the Weight; then the beſt *Aqua Fortis* poured upon it is not capable of diſſolving the Silver: but if you add more Silver to this Maſs melting in the Fire; then indeed *Aqua Fortis* poured upon it, when it is grown cold, will corrode the Silver from it: which is alſo the more ſtrongly performed, as the Quantity of the Gold is leſs than one third Part of the whole Maſs. But Experience has taught us, that *Aqua Fortis* diſſolves Silver mixt with Gold quickly enough, when the Gold conſtitutes but one, and the Silver three quarter Parts of the Maſs: Nay, if the Solution is not too impetuoſly performed, the Gold commonly retains in ſuch a Proportion, without any Alteration, the ſame Figure which the whole Maſs had before the Diſſolution; ſo that in this Caſe there is no Reaſon to apprehend, that the Gold torn into minute Particles will be diſſipated in part: which can hardly be prevented, when the Silver exceeds the three quarter Parts of the Maſs with regard to the Gold.

* In Engliſh *Parting*.

Therefore, Artificers make it their Study, always to observe exactly the Proportion just mentioned: Whence, the Reason and Origine of the Name *Quartatio* †, is self-evident.

Coroll. Now, from what has been said (§ 471.) it is easy to conclude, how fallacious the Examination is made with *Aqua Fortis* alone (§ 303.) of the Gold that has been rubbed against the Touch-stone.

473. Edulcoration * is called a kind of moist (§ 471.) Solution, when the saline Part adhering to a solid Body not dissoluble in Water, is dissolved by an aqueous Fluid; and then the Solution is separated from the remaining Solid, either by subsiding, or by being passed through a Filtre; and this is repeated over and over, till there remains no sensible Quantity of the saline acrid Body.

474. It is proper in this Operation (§ 473.) to enlarge the Surface of the Body to be edulcorated, by pounding of it; that the Solution may have a speedier Success: for which Purpose indeed, they moreover break it in Pieces, or stir it with a Stick: That all the Particles of the Body to be edulcorated, which otherwise would sink to the Bottom, may on all Parts be contiguous to the Particles of the washing Fluid: by which Artifice all Solutions are facilitated. Likewise, boiling Water is sometimes requisite: for the Heat, by the inward Motion and Rarefaction it occasions, promotes in an extraordinary Manner all saline Solutions.

475. However, a perfect Ablution of the Salt, is not always obtained by this (§ 474.) Method: for, as every Part of the Menstruum, contains in it, a proportionable Quantity of the Body to be dissolved (§ 471), and there remains always some Part of the Menstruum in the Body to be edulcorated; it is as evident as Light itself, that there remains at the same

† That is, literally translated, *Fourthing*, because the Gold must be but one *fourth*, when the Silver is three *fourths*.

* Or washing from the Salts.

Time a proportionable Part of the Salt, answering to the remaining Quantity of the Menstruum. Let us take for an Instance the salt, alkaline, Ashes of Woods: pour upon them hot Water; make this boil together with them for some Time; and then by Decantation or Straining, separate the Lye from the rest: There will remain at least one quarter Part of the Lye among the Ashes; and of Course also a proportionable small Part of the dissolved Salt itself: pour fresh Water a second Time, and decant it: A Quantity of Salt, though much less considerable, will for the same Reason again remain; and so on for ever. For which Reason, this Operation must be repeated, at least so often as that there remains but a very small and insensible Portion of Salt.

Coroll. Hence, the Reason is plain, why Calxes of Gold and Silver made with Acids are so frequently reduced with great Loss: for the Acids as yet adhering, being agitated by an impetuous and especially an open Fire, carry a great Quantity of Metal away with them; not even excepting *Aqua Fortis* itself; which nevertheless, is said to be, and in reality is of a fixing Nature, but that only with certain Limits.

476. Precipitation is called moist, in German *Fällung*, when a Body, which has been dissolved (§ 471.) the moist way, is again driven out of the Dissolvent, so as either to swim in the Menstruum, or to sink to the Bottom of it: which most commonly looks like Powder; but the Separation of the Menstruum from the Body precipitated, is afterwards performed by either decanting, or filtrating.

477. This Operation (§ 476.) is performed, either by extracting, or evaporating in a gentle Fire, the dissolving Menstruum out of the fixt dissolved Body; or by adding such a Body, as is greedily dissolved by that Menstruum: as if one Metal dissolved in an Acid, is precipitated by another Metal, or by alkaline Salt; for Instance, Silver dissolved in *Aqua Fortis*, precipitated by Copper, Copper by Iron, Iron by Zink, and all Metals and Semi-Metals either partly,

partly, or intirely by pot-Ashes, volatile and urinous Salts. In short, a Precipitation is also made by pouring such Things as cannot dissolve the Body in hand, either alone, or joined to a *Menstruum* that contains the said Body, or at least dissolve it in another Manner, or even in a lesser Quantity, than if the *Menstruum* had at first been used pure. In the first Case, a total Precipitation is performed, as may be seen in the Precipitation of Silver out of *Aqua Fortis*, made by Spirit of Salt. In the second Case, a great Deturbation and Precipitation is made; but a second Solution soon follows: As it happens, when Iron being dissolved in *Aqua Fortis*, you add to it, in a proper Manner, a Liquor perfectly clear from alkaline fixt Salt: but then there remains most commonly a certain Part, which is not perfectly dissolved a second Time. In the third Case, there is but a partial Precipitation made: You will have an Instance of this, if Mercury dissolved in *Aqua Fortis* saturated with it, is precipitated by common or ammoniac Salt, or by their acid Spirit. A Precipitation is also sometimes made by adding only a Quantity of Water to dilute: Such is that made with *Regulus Antimonii*, dissolved in Spirit of marine Salt, or in *Aqua Regis*: For these *Menstrua* do not dissolve this Semi-Metal, unless they are concentrated.

478. All this Precipitation (§ 477.) is helped on by a moderate Heat; by Means of which the precipitating Body enters more easily into the *Menstruum*. Then, you must have a considerable Quantity of Water to dilute with, except in the first Kind of Precipitation: For most commonly, the more concentrated Dissolutions, assume the Consistence of a Paste, so soon as the precipitating Body is added to them; which hinders this from mixing equally with the Solution.

479. We might annex to moist Solutions (§ 471.) the Elutriation *, which is made, when solid Bodies

* Or washing with plain Water.

not dissoluble in Water, are separated from each other by Water very well stirred, so as that the lighter, together with the more subtle Ones, may be forced out of the Water, and the heavier and more solid, that is, those which resist more, may remain at the Bottom of the Vessels. See what was said before (§ 337.) of this Operation.

C H A P. VI.

Of the Effects and Use of the Art of ASSAYING.

480. **T**HE chief Effects of the Art of Assaying, are to purify Metals, Semi-Metals, and other Fossils, of all the heterogeneous Bodies they are found mixt with by Nature, and to separate them therefrom: Nor has the Assayer any other Aim in all his Undertakings, as will more clearly appear in our practical Part: For which Reason we shall not at present descend to Particulars.

481. Nor is it very difficult from thence to conceive, how useful and necessary is that Art, which at the same Time that it consists in the Knowledge and Separation of Minerals, and in the appropriating them to the Use of Men, affords besides an infinite Number of Benefits to Chemists, Handicrafts, Physicians, Naturalists, Metallurgists, &c. The Art of Assaying is nothing but Metallurgy brought into a narrower Compass: Therefore, whoever has perceived the Usefulness of the Latter, can never question that of the Former. For if the Properties and Nature of a Mineral found, were not previously detected by docimastical Operations; who would dare to be at so considerable Charges, for the making of a greater Apparatus? which must be chiefly understood of Silver, and of the Gold concealed in it: Because these Metals are most commonly so intimately

mately adherent to other Metals, that they cannot be distinguished by the bare Sight.

482. Besides, Assaying is necessary to the other Arts, wherein the Knowledge of the Mixture or Pureness of Minerals, as well as the Purifying of them, or the several Compositions thereof, are required. For this Reason, its Usefulness is very great, chiefly in that Part of Physick called the *Materia Medica*: Because there are a great many Minerals made use of in Medicines: Therefore, a Physician must know them, as so many Instruments of his Art: Unless he will run an equal Chance, of either hurting or doing Good, or even of doing nothing at all. This will be easily granted by every one that knows, how secretly the most poisonous Minerals, such as Arsenick, Copper, Lead, &c. lie hidden in all the Species of Minerals: So that all of them, whatever they may be, ought to be previously committed to the strictest docimastical Examination, before they are received into the Shops of Apothecaries.

483. But they above all bestow their Trouble in vain, who being ignorant of the docimastical Art, yet attempt to make alchemical Operations, as these, among other Particulars, have in view both the Perfection of Metals, and a thorough Knowledge of them. Nor is there any more ridiculous Thought, than to pretend to bring Metals to a greater Degree of Perfection and Pureness, and at the same Time to be ignorant of the common Knowledge of, and the Manner of separating them, a Title they give to the docimastical Art *. Whence it is no wonder, that Quacks and Boasters very frequently spend great Riches about the most trifling Operations.

484. The utility of Assaying extends also to the Art of making Glafs. When any, for Instance, has a Mind to make Glasses of the Colour of Jewels †.

* By way of Contempt.

† Thus are made the *Pastes* for imitating antique Gems: and on this depends the whole Art of *Enameling*.

For, in order to this, the Calxs of Metals are most commonly necessary: Because, the Calx of every Metal, even the least Quantity of it, tinges Glasses with a specifick Colour. Therefore, that you may with Certainty produce the Colour desired, it is necessary that your Metals be of the utmost Pureness: Now, this can never be effected without docimastical Operations: For, when but one thousandth Part of Metal mixes to the Tritt of which Glass is made, that is to the Mixture of Salts and Flints, to which Litharge or Lead-Calx is sometimes added, your Glass is immediately tinged with some Colour, whereas it was to have none, but be quite crystalline. But if you are willing to give your Glass a certain Colour, to be produced by the Addition of one or many Metals, another Metal mixt with it in ever so small a Quantity, changes it entirely; hence it is so very difficult to give the purest Ruby-Colour to Glasses.

485. But the Knowledge of the Art of Assaying, is likewise absolutely necessary, in the making of physical Experiments, especially such as have a Relation to the Nature of Fire, and its Effects upon mineral Bodies: That you may know, whether the Body under Trial is pure, or no: Unless you have a Mind to indicate an uncertain Cause for a certain one, and to see always some new Event resulting from the Repetition of the same Experiment. I might here alledge many Reasons, to demonstrate this Assertion: Were I not obliged either to call in Question with great Reason, or intirely to annihilate those Experiments, which are so much valued by the Multitude, and illustrated with Speculations which their Authors are extremely fond of. But a *Word to the Wise is enough!*

The End of the Theory of the Art of Assaying.

THE
ART
OF
ASSAYING
METALS.

PART the SECOND,
Being the PRACTICE of ASSAYING.

Wherein the Manner of performing the doctrin-
astical Processes is taught.

Preliminary Discourse.

Chemists call *Processes* those Apparatus's, by which they perform those Actions, whereby certain determined Changes are produced in the Objects of their Art. Therefore they have been in another Place (Part I. § 443.) called Operations. For as a simple Action, when alone, cannot always effect the desired Change; it is easy to conceive, that, not only simple Operations, but also many of them combined together in a thousand different Manners, are comprehended in the Processes. Whence it happens, that so great, nay, an infinite Number of Processes may be composed of the few Operations we have (Part I. Chap. V.) mentioned: For according as these are variously employed and managed about the same Subject, so there are many various Processes occasioned,

occasioned, and as many Effects produced upon the Object; though these different Series of Operations, do not always answer the Intention of the Artificer. Therefore, as the Change of the Subject, which is our chief Purpose, cannot be perfected in the Processes by a simple Operation; it is evident, that we cannot here proceed according to that Series which we have given (Part I. § 448), in the Table of Operations; partly, because, in the proceeding, the greatest Skill consists, in chusing the Operations necessary for the Change proportionably to the Variety of the Subject, and the Intention, and in composing them suitably; which cannot be done, when any Process is resolved into its simple Operations, and these afterwards grammatically referred to one and the same Class: Partly, because a great many chemical Operations, not properly belonging to our Subject, nor even mentioned, are often made use of in a subsidiary Manner; for Instance, Distillations, Evaporations, Crystallizations, and the like. For, in the Explication we are about to give of the doctrinastical Processes, our chief Regard must be, to satisfy the Understanding rather than the Memory of Beginners; that it may be an easy Matter for them to imitate the Processes explained to them. We gain the first of these Ends, by giving the first Rank to those Processes, which being of themselves intelligible, require not the Knowledge of the following, but are rather of Help, for the better Understanding of them, or at least suppose nothing of what follows, that may not immediately be explained in a few Words, or be understood from what precedes, by Help of a short Theory. Likewise, those that are more easy to be done, must, as much as possible, be put before the more difficult. Then, if many Operations are required for producing the Effect, it will be proper to divide the whole *Apparatus* into some Processes, lest, being so numerous, they should perplex one another; and, as much as possible, to consider separately the different Changes, after having deduced

them separately. For the same Purpose, likewise, we shall subjoin to the Description of every *Apparatus*, the several Manners of proceeding, and every Thing moreover to be observed; lest all these things being dispersed, should avert the Attention from the Description itself of the Work, or puzzle the Beginner. But, it will not always be possible to fulfill every one of the Rules hitherto established; because the First and Second chiefly, will now and then bear an Exception, to avoid a greater Inconvenience. For this Reason, it is not always convenient to give the first Rank to the more simple Processes, because they are performed with greater Difficulty; nor to give it always to the more easy, because they require a previous Knowledge of some of the foregoing to be brought to their Perfection. We must then be allowed, to select several Series of Processes, and out of these, well composed among themselves, to establish the most convenient Order. We then thought it very proper, to begin with those Processes which are made with Silver and its Ores: For in these, there is no Necessity but of a simple Separation of the heterogeneous Bodies; and even this is performed by Additions more simple than in the others; wherein, besides this Separation, an intimate Combination of the *Phlogiston* is required, for a Reduction into a metallick State. Next, the Effect of the *Menstrua* is most commonly evident to the Senses, in Operations made upon Silver, during the Action itself: Wherefore, the Degree of the Fire may be measured as with the surest Thermometer: Which does not succeed so well in the Processes to be used for the other Metals; because these, most commonly, must be treated in close Vessels, on account of their Destruetibility. And this Destruetibility itself is the Cause, why these Processes so seldom meet with good Success; because the Greatness and Duration of the Degree of the Fire, are very difficult to be exactly determined; and the Effect, while it is produced, cannot be seen; but, when the Process is finished, then, indeed,

indeed, and no sooner, you are capable of determining, whether it has succeeded well, or no. Besides, as Metals, Semi-Metals, and the other Minerals, all of them undergo a Trial, to know whether there is any Silver in them; their Disposition in the Fire and in the several Menstrua, appears with the greatest Evidence in these Processes; and by it, the Processes to be made with them afterwards, are indeed very much facilitated. These Processes must be followed by those that are made upon Gold: For these, in many Respects, have a great Affinity with the foregoing; besides that both a greater Variety of Operations, and now and then difficult manual Works, are met with in these. The Reason of the Order in which the Processes are to follow each other, with the other Minerals, will appear from the Way itself of treating them.



DOCIMASTICAL
OPERATIONS
UPON
SILVER, and its ORES.

PROCESS I.

Precipitation of Silver (Part I. § 452, 467.) made with Lead; by Scorification, out of its easily-fusible proper (ibid. § 385—388.) and improper (ibid. § 389—391) Ore.

The APPARATUS.

1. **P**OUND the Ore in a very clean Iron-Mortar, into fine Powder. Of this weigh onedocimastical Centner (*Part. I. § 275*); and eight the like Centners of granulated Lead.

2. Then have at hand the docimastical Test (*Part I. Plat. I. Fig. 7.*) which must not have as yet served to any Operation: Pour into it about half of the granulated Lead (N^o. 1.) and spread it with your Finger, through the Cavity of it. Then put upon this Lead the pounded Ore (N^o 1), and then cover it quite with the Remainder of your granulated Lead.

3. Put the Test thus loaded under the Muffle of the assay-Furnace (*Part I. Plat. III. Fig. I.*), and in the hinder-Part of it: Then make your Fire, and increase it by the Degrees mentioned (*ibid. § 235.*) If you look through the Hole of either of the Sliders (*ibid. Plat. III. Fig. I. m. n.*) you will soon see, that the pounded Ore will be raised out of the melted Lead, and swim upon it. A little after, it will grow clammy, melt, and be thrown towards the
Border

Border of the Test: Then the Surface of the Lead will appear in the Middle of the Test, like a bright Disc, and you will see it smok and boil (*Ibid.* § 38). So soon as you see this, it will be proper to diminish the Fire a small Matter, for a Quarter of an Hour; so as that the boiling of the Lead may almost cease. Then again, increase the Fire to such a Degree, that all may turn into a thin Fluid, and the Lead may be seen, as before, smoking, and boiling with great Violence: The Surface of it then will diminish by Degrees, and be covered over with a Mass of Scoria's. Finally, have at Hand an Iron-Hook (*Part I. Plat. IV. Fig. VI.*) ready heated, wherewith the whole Mass must be stirred, especially towards the Border; that, in Case any small Parcels of the Ore not yet dissolved should be adherent there, they may be brought down, taking great Care, not to stir any the least Thing out of the Test.

4. Now, if what is adherent to the Hook during the stirring, when you raise it above the Test, melts quickly again, and the Extremity of the Hook grown cold is covered with a thin, smooth, shining Crust; it is a Sign that the Scorification is perfect; and it will be the more so, as the said Crust adherent to the Hook, shall be coloured equally on every Side. But in Case, while the Scoria's are stirred, you perceive any considerable Clamminess in them, and when they adhere in good Quantity to the Hook though quite red hot, and are inequally tinged, and seem dusty, or rough with Grains interspersed here and there, it is a Sign that the Ore is not entirely turned to Scoria's. In this Case, you must with a Hammer strike off what is adherent to the Hook, pulverize it, and, with a Ladle (*ibid. Plat. IV. Fig. XI.*), put it again into the Test, without any Loss or Mixture of any foreign Body, and continue the Fire in the same Degree, till the Scoria has required its Perfection and the above-mentioned Qualities. This once obtained, take the Test with a Pair of Tongs (*ibid. Plat. IV. Fig. II.*) out of the Fire, and pour Lead together

together with the Scoria swimming upon it, into a Cone (*ibid.* § 224, 225.) made hot, and rubbed with Tallow. Thus will the first Operation of the Process be performed, which does not commonly indeed last above three Quarters of an Hour.

5. With a Hammer, strike the Scoria's off from the Regulus grown cold, and again examine whether they have the Characteristicks (N^o. 4.) of a perfect Scorification: If they have, you may thence conclude, that the Silver has been precipitated out of the Ore turned to Scoria's, and received by the Lead.

When the Scorification lasts longer than (N^o. 4.) we mentioned, the Lead at last turns to Scoria's, or Litharge and the Silver remains collected at the Bottom of the Vessel: But the Fire must be moderately supplied, and the Vessels be extremely good, to produce this Effect; for they seldom resist to the Strength of the Scoria's of Lead long enough, so as that the whole Scorification of the Lead may be brought to an End: Which has afterwards this Inconveniency, that the Silver is dissipated by Grains in the small Hollows of the corroded Ore, and can hardly be well collected again, when the Ore has but little Silver in it: Nay, there is still more Time to be consumed, to obtain the perfect Destruction of the Lead, by Means of the combined Actions of the Fire and Air, because the Scoria's swimming at the top retard it considerably.

The Use and Reasons of the Process.

1. The State of the Silver-Ore depends upon the Prefence of Sulphur and Arsenick: Both these, when they are not very strongly inherent to the Silver, and when the Ore is broken small, and extended widely in a small Quantity, are in Part easily dissipated by the Fire, and in Part absorbed by the Lead (*Part I.* § 76, 174. *Coroll.* 2.) the lighter Part of which swimming upon the heavier becomes very clammy By means

means of the Sulphur which is in the Ore; but when this is dissipated by the Violence of the Fire, it turns into Glass or Scoria's. But when Arsenick is predominant in the Ore; the plumbeous Part turns immediately into a very penetrating, and very fusible Glass, having a dissolving Efficacy, unless the Arsenick lies hidden in a white Pyrite or Cobalt. For this Reason, the fixt Part of the Ore, which is no Silver, is dissolved by that Glass, melts, and assumes the Form of Scoria's: The unmetallick Earths, and the pure Copper or Lead-Ores thereto adherent, are of this Kind. The Silver then remains immutable, and being freed of these heterogeneous Bodies, which are perfectly dissipated and partly melted, it is precipitated, and received by the remaining *Regulus* of Lead. Therefore this Process is completed by three distinct Operations; viz. (1.) by roasting, (2.) by Scorification; (3.) by the melting Precipitation of the Silver, which is the Result, of the two former Operations.

2. The Ore must be pulverized very fine, in order to increase the Surface; that the Dissipation of the Volatiles, and the Dissolution by Litharge may be the sooner effected. This pulverising must then be done, before the Ore is weighed, because there is always some Part of the Ore adherent to the Mortar, or the Iron Plate on which it is made fine; which Part being lost, the Operation is not exact. *Erker* was in the right, when he prescribed 8 Centners of Lead, for the subduing of the fusible Ore: Nevertheless, it must be owned, that this Quantity is superfluous in some Cases: However, as the Fluxibility of Silver-Ore depends from the Absence of Stones, Pyrites, &c. it is easy to see, that there are an infinite Number of Degrees of Fluxibility, which it would be needless to determine exactly, and most commonly very difficult to determine by the bare Sight. Besides, a little more Lead does not render the Process imperfect; on the contrary, if you use too small a Quantity of Lead, the Scorification is never completely

pleatly made. Nay, there are a great many Ores, containing Sulphur and Arsenick in plenty, that destroy a considerable Quantity of Lead: Such are the red Silver-Ore, and that wherein there is a great Deal of the steel-grained Lead-Ore,

3. When you intend to make a perfect Process, it is not proper to make one and the same Test serve for many Processes, but you must always chuse a new one: For in all Processes, you must take Care that no foreign Body may accrue to that in hand, or that nothing may be lost of the Weight already determined: Which will easily happen, if you use old, unclean Vessels and Instruments.

4. There are some, who wrap up their Ore in a Paper, or put it into a small Ladle, and hold it thus upon hot boiling Lead: But we reject this Method, because the Volatiles, especially the Arsenick, being agitated by so sudden and violent a Heat, may carry off along with them a great Deal of the Silver: There are likewise many Ores, but chiefly the red Silver-Ore, which being exposed to a sudden, violent Heat, burst asunder and disperse; or if they don't do so, at least you will never be certain, whether there are not Particles of Flint, Spaad, Allum, and other Stones interposed, which crackling, may easily sling some Part of the Ore out of the Vessel along with themselves. To prevent this, it is enough to cover the Ore with granulated Lead: For then the Ore grows warm by degrees, and as its Particles, when bursting out, must go through the melted Lead that covers them, they are so much involved by its Calx grown clammy, that they cannot leap out.

5. If the Fire must sometimes be diminished in the Middle of the Process, it is in order to hinder the too much attenuated Litharge, which is continually generated out of the Lead, from penetrating the Pores of the Test, and from corroding it: Which is easily done, when the Fire is over-strong: For then the Surface of the Vessel, which is contiguous to the Lead, contracts Cavities, or being totally consumed

by small Holes, lets the *Regulus* flow out of it. The Vessels that are most subject to this Inconvenience, are those in the Materials of which, Lime, Plaster, and Chalk are mixt: Nay, these Bodies, which are of their Nature refractory, being eroded during the Scorification, at the same Time communicate a great Clamminess to the Scoria; so that a great Quantity of the Mass remains adherent to the Test, in the Form of Protuberances, when you pour it out; whereby a great many Grains of the *Regulus* are detained.

6. There are a great many Assayers, who take for a Sign of the Compleatness of the Scorification, the Quantity of the Scoriæ; that is, when these have covered the whole Surface of the Lead. But this is very uncertain: For, if the Test is a small Matter narrower, and of Course as much deeper, or if you scorify Silver-Ores that are less rich; then indeed the *Regulus* of the Lead will be covered over with the imperfect Scoria, long before the Scorification is perfect. The Quality of the Scoria is a much surer Sign; and this must appear quite vitrified, according to the Description of it given (N°. 4. of the Appar.) In the mean Time, the Colour and Brightness of it differs according to the Variety of the Ore; however, it is most commonly brown, or black, and opaque, which is owing to the Iron and Copper, from which the Ore is seldom altogether free; For these Metals tinge Glasses with very deep Colours. The Colour of the Scoria is seldom half transparent, reddish, or yellow, like Rosin. But when these Characteristicks are wanting, you may be sure, that all the Silver is not yet precipitated out of the Ore, as it ought to be: Therefore the Fire must be increased.

PROCESS II.

*The Separation of Silver out of the Regulus, Proc. I. by
coppelling (Part I. § 454.)*

THE Separation of Silver out of Lead, when it has been precipitated, and received by the Lead, may indeed be intirely made by the *Apparatus* of the foregoing Process as well as (*Proc. I. Appar. N^o. 5*). But this Method is tiresome, on account of the Inconveniencies mentioned in the same Place: Therefore, the Thing is better done by coppelling. But for this Reason a Scorification must precede; that those Bodies, which greatly resist a sufficient Attenuation to be effected by the Scoria of Lead, may be previously separated, and that the Addition of so great a Quantity of Lead may not be necessary.

APPARATUS.

1. Put into the docimaistical Furnace under the Muffle, two Coppels of the same Bigness (*Part I. Plat. I. Fig. III.*) perfectly dry, and of such Capacity, that they may contain a Regulus, at least one third Part larger than that which is to be put into them: Make a strong Fire, that they may be red hot for a Quarter of an Hour, or more, and the aqueous Vapours vanish intirely. Then free your *Regulus* quite from Scoria's, by several gentle Blows of a Hammer, wrap it up in a clean Paper, and put it into the Fire gently with a Pair of Tongs; taking great Care, that the hollow Surface of the Coppel be not hurt: For which Reason, you must also take Care, that this be not angular or rough. Now, with a Ladle, put into the other Coppel as many Centners of the same granulated Lead, which you have used (*Proc. foregoing*) for the Scorification of the Ore. All the Phenomena will appear the same as we have described (*Part I. § 38*), and the Scoria's

which are perpetually produced by the Lead, being cast upon the Border, will be immediately absorbed by the Coppel, which, on this Account, will be tinged with a yellow, brown, black Colour, in proportion as the Scoria shall have penetrated into it.

2. But so soon as you see the *Regulus* boil with Violence and Smoke, diminish the Fire a little; that the *Regulus* may for the greatest Part be consumed by a middling Heat. You will know that the Degree of the Fire is very great, if the Smoke proceeding from the Lead, is driven up almost to the very Cieling of the Muffle, and if the *Regulus* in the Coppel is gibbous at Top: In which, however, the Quantity of the Metal is to be considered: For a large Mass of *Regulus* makes the spherical Segment low, and a lesser one makes it more acute, when the same Degree of Fire has been used for each of them. Then, if the Coppels are so bright with the Fire, as that it be hardly possible to distinguish how far the Scoria has entered, it is a Sign of a still greater Degree of the Fire. But you will know that the Degree of the Fire is middling, if the Surface of the melted Metal is plain, if the Smoke does not rise very high, and if the Coppel is coloured by the Scoria's, which Signs indicate that the Fire wants a Degree of Force. But if the Smoke wanders to and fro on the Surface of the Metal; if this is almost flat, and the Ebullition of the Scoria's, which are like Drops of Fire, is but weak, and their Motion languid, if in short the Coppels appear dark, it is a Sign that the Fire has not its sufficient Degree of Strength.

3. If you see the *Regulus* considerably diminished, the Fire must still be increased: The Lead being thus considerably diminished, the bright Sparkles will disappear, and instead of them, you will see *Iris's*, as it were, much livelier than in the Beginning and the Middle of the Operation, quickly moving on the Surface of the *Regulus*, and crossing each other many different Ways. When at last all the Lead is consumed, the tender Skin of the thin Scoria

or Litharge, which being perpetually reproduced by the *Regulus*, had covered the Surface of it, is as it were pulled off. If the Fire at that Time is not strong enough to keep the Silver in a State of Fusion; the Colour of the *Regulus* of Silver remaining, changes suddenly from a faint fire Colour, to a shining one: Which Brightness is called in German **Blicker**. But if you have used in the End so great a Fire, as that the pure Silver may be kept in Fusion, this Alteration of Colour, does not appear, but the granulated Metal continues to shine bright. Silver, in the Moment it grows solid, commonly emits out of itself Ramifications like a Vegetation, and which are sometimes very delicate and elegant.

4. When the Phenomena above-mentioned (N^o. 3) have been seen, leave the Coppel still one or two Minutes under the Muffle; then take it out, and with a Pair of Tongs (*Part I. Plat. IV. Fig. III.*) take away the Metal in Grains: And if any Scoria or any Bit of the Coppel should happen to adhere to it, wrap it up in a Paper, and press it between a strong Pair of Tongs or between the Chops of a Vice: That the brittle Dross may go off without Loss of the *Regulus*; which shall be very white, and full of small Pits underneath: But if it is tinged with a neat yellow Colour; you may be sure that it contains a great Deal of Gold.

5. If you want next to determine how much Silver you have fetched out of the Ore, put in one Scale the Silver-*Regulus*, which has remained of the *Regulus* in the Scorification; and put in the opposite Scale, together with the Weights, the *Regulus* which remained in the other Coppel, out of the same Quantity of granulated Lead, as you have used for the Scorification: For the Lead by which the Scorification has been made contained as much Silver; and this has joined itself by the Force of the Operations, to the *Regulus* obtained out of the Ore.

The Use and Reasons of the Process.

1. When you are chusing a Coppel, you must have Regard to the Capacity of it; for Instance, whether it answers the Quantity of Metal to be put into it, or no. Too large a Size is no way detrimental, but only uselefs. Whereas, if it is too small, the Operation does not succeed well. For if the Coppel is loaded with too much Lead, the Inside of it is at last corroded and split, by the Litharge into which the Lead is dissolved, and which finally consumes every Thing: Nay, if the Ashes of the Coppel are already saturated, a greater Quantity of the Litharge cannot get into it so quickly, and that Part of it, which is then absorbed, runs through upon the Bottom of the Muffle: Which has this Inconvenience, that when the said Bottom being corroded grows unequal, the Vessels put into it do not afterwards stand steddy, and are conglutinated to it, if the Heat is considerably increased.

2. The Coppels, though extreamly old, and to Appearance very dry, like many other Bodies, being nevertheless exposed to a strong Fire, exhale a moist Vapour, as we learn from chemical Distillations: But above all, the Ashes of Wood do not easily part with the Moisture they have once contracted, because of the Salt from which they can hardly be intirely freed. Therefore, those Coppels chiefly which are in part composed of Wood-ashes, must previously be made thoroughly red-hot under the Muffle, without any Lead put into them, that all the Moisture may be dissipated. This roasting is called in German *Abathnen*. But if this is not done sufficiently, the Lead put too soon into the Fire, flings to the very Cieling of the Muffle, an innumerable Quantity of small Drops like Sparkles, with a gentle crackling Noise. And as this Lead has in it a proportionable Quantity of Silver, it renders the Process uncertain. This emission of Sparkles, when perceived soon enough

enough by the Artificer, may indeed be at any Time prevented, by a large Coal that closes the whole Cavity of the Coppel, when put upon it like a Tile : But, as some Metal flies off when this Defect is first observed, and before it can be remedied, on this very Account, an exact Assayer can never trust to such a Process. Besides, the Operation is also retarded by this Remedy : For scorified Lead, is often reduced by the Phlogiston of the Coal ; wherefore this must be removed so soon as the Lead begins to rest. It also sometimes happens, when you neglect to heat the Coppel sufficiently, that the Lead continually quivers in the Coppel ; so that it never settles ; and thus changing its Place, it now and then is in Part thrown out of the Coppel. This Fault may be better prevented, by putting a larger Coal upon the Coppel, than the foregoing : Which proceeds from the Eruption of dry, fat Vapours.

3. Let the Fire be somewhat gentler, in the Middle of the Operation of coppelling ; lest something of the Silver should be carried away, by the too attenuated Litharge, and by the Smoke itself of the Lead : For in every dry, as well as moist and too turbulent Dissipation of the Volatiles, a Part of a Body howsoever fixt, may at the same time be hurried away. That degree of Fire is here sufficient, by which Lead is changed into Litharge, and attenuated so far as to be able to penetrate the Coppel. But when in the End of the Operation, the Lead is almost all consumed, the Fire then must be made very strong ; lest something of the Lead should remain with the small Silver-Mass : Whereby the Weight becomes uncertain, and the Silver is rendered brittle. For Lead is destroyed into a sufficiently attenuated Litharge, by a much lesser Fire than is necessary to melt pure Silver : And Lead acts here as a *Mensstruum*, by which you obtain the melting of Silver in a weaker Fire : For this Reason, the more the Lead is consumed, the stronger the Fire must be made, than the Quantity of Lead requisite to retain

the *Regulus* in a State of Fusion, being once deficient, it may be compensated by the Violence of the Fire: Which being neglected, the *Regulus* of the remaining Silver hardening too soon, a Part of the Lead preserved from its Destruction by the Silver, remains joined to it. Such a residuous Part of Lead adhering to the Silver, is called in German *Weyssack*.

4. The Operation of coppelling being done, the Grain or Bead of Silver must be taken out of the Fire with all Speed; lest growing cold, it should be conglutinated to the Coppel by the Litharge: For otherwise, it can hardly be taken off, without Part of the Coppel adhering to it. The Coppel may also be left a while with its Bead under the Muffle, and this is better; that all the Litharge may retire into the Coppel: For then it is very easily taken out. As for the rest, you may see *Part I. § 181. Coroll.* The Operation of Coppelling being duly perfected, the Bead of Silver will be full of small Cavities underneath.

5. By these two Processes (I. and II.) is completed the docimaestick Examination of a fusible Ore, whereby it appears how much Silver may be fetched out of it with Benefit, by a metallurgical Operation: For both being joined, answer exactly to the great Operations of Metallurgy. There are some of these Operations, which those that are well versed in the Matter, can perform together, at once, and under the same Muffle; provided one Vessel is no Impediment to the other. At least the Coppel may be conveniently heated, at one and the same Time, and in the same Fire, while the Scorification is performed in the Test.

6. There is no Lead sold, but contains some Silver: For it is not always worth the Charges of separating it. Such a little Mass of Silver most commonly is one or two Drachms in every Centner of Lead. Therefore, it occasions a very great Error, when it is left in the Coppel, and joins to the *Regulus*.

lus separated from the Ore after the Lead is consumed: For which Reason, this increasing of Silver is always substracted by all accurate Assayers. Therefore, a considerable Quantity of Lead is granulated at once for this Purpose, and well mixt by sifting: Then this granulated Metal alone, must be tried in a Coppel, in the same Quantity used to make the Trial of Ores; that you may have separately the Bead of Silver it contains. For this, while the *Regulus* of Silver, separated from the Ore by the same Kind of Lead, is weighing, is put into the other Scale which contains the Weight; to take away the Overplus of Weight, that was added to this *Regulus*, by the same Quantity of the Lead imployed for the Scorification and Coppelling. But whenever a Granulation of new Lead is made, the determined Quantities of it commonly imployed for the trying of Ores, must be as many Times tried in the Coppel; even though you knew, that the Lead had also been digged out of the same Mine as the first, and melted out of its Ore in the same Manner. For while Lead is smelted, Silver is not very equally distributed through it: Which proceeds from many Causes, of which hereafter.

7. However, we must also observe in general, that all the additional Ingredients, which we use in such Operations, must be tried, to know whether they let any Silver fall into the *Regulus* of Lead, and how much. For the Litharge itself is sometimes loaded with Silver. Therefore, it is proper to try it itself in the Coppel, or the Glass of Lead made out of it, before they are imployed. Copper, Iron, and other Metals, are seldom altogether destitute of Silver: And though they contain so little of it, that the Error proceeding therefrom is hardly sensible; nevertheless, you must beware of the minutest Mistakes: For a great Number of them, though ever so insignificant, constitute, when collected together, an Error, which is not inconsiderable.

PROCESS III.

To precipitate with Lead by Scorification, Silver out of an Ore that cannot be washed clean, and which is rendered refractory, by a Mixture of unmetallick Earths (Part I. § 334, 336, 338.)

THE Variety of those Things which render Ores refractory require a different Manner of treating them. But there are some Ores rendered refractory, by a Mixture of an unmetallick Earth, some of which are, and some are not separable by washing. If they are not separable, you must proceed in the following Manner.

APPARATUS.

1. Bruise the Ore into an impalpable Powder by grinding in a Mortar; to a docimastical Centner of it, add a like Quantity of Glas of Lead (*Part I. § 54.*) finely pulverized: For the more exactly both these are mixt together, the more easily the Scorification afterwards succeeds. Put this Mixture, together with twelve Centners of Lead, into the Test, according to the first Process (N^o. 2.) then put the Test under the Muffle.

2. Make first under it a strong Fire, till the Lead boils very well: When you see it so, diminish the Violence of the Heat, according to the first Process (N^o. 3.) but keep it thus diminished a little longer. Then, finally, increase the Fire again to such Degree, till you perceive the Signs of a Scorification and perfect Fusion. See the whole Process I. Now, this Process lasts a little longer than the foregoing, and requires a greater Fire towards the End.

3. It sometimes happens, that a very refractory Ore cannot be sufficiently dissolved by Litharge; and that a Mass which has the Clamminess of Pitch, swims upon the Regulus, and upon the Scoria's them-

themselves which are already subdued in part : When you see this, shut the Vents of the Furnace, to diminish the Fire : Then gently touch this refractory Body, with a small Iron cold Hook, to which it will immediately stick ; take it off softly, not to lose any Thing ; pound it into a fine Powder, adding a little of Glass of Lead ; and put it again into the Test, then continue the Scorification, till it is brought to its Perfection. But you must always examine the Scoria of your refractory Ore ; to see whether there may not be some Grains of the *Regulus* dispersed in it : For sometimes the Scoria's that grow clammy, retain something of the Metal : Which if you suspect, pound the Scoria into a fine Dust, and thus the Grains of Metal will appear, if there are any left ; because they can never be pounded fine.

4. Silver is separated out of the *Regulus* by copelling (N^o. 3), according to Process II. But while you are weighing the *Regulus* of Silver obtained, you must put into the opposite Scale, the small Mass of Silver, which has remained in the Coppel, out of the twelve Centners of the Lead employed. (See Process II.)

The Use and Reasons of the Process.

1. All Earths and Stones are refractory in the Fire : For though some of them melt naturally in the Fire, as those that are vitrifiable do ; nevertheless, all the others, a very few excepted, melt much more difficultly than Metals, and never become so thin in the Fusion, as is required for the sufficient Precipitation of a precious Metal. But Litharge itself does not conveniently dissolve these refractory Matters by the Help of Fire alone, unless you add some mechanical Mixture to them : For the very Moment the said Litharge penetrates through the Interstices of the refractory Ore, and begins to dissolve it, a tenacious Mass is produced, which hardly admits any further Dilution by the Litharge. You may see it plain, if you make Coloured Glasses with metallick Calxs : If
you

you pour carelessly upon them a Calx that gives a Colour, you will never obtain that they may be equally died on every Side; even though you should torture them for whole Days together in a great Fire. Nay, Glass already made, can never be perfectly diluted, by only pouring Salts and Litharge upon it: Wherefore, you must use the Artifice of Glass-Makers, who, in the making of the most perfect Glasses, take great Care, before they put the Species of their Ingredients into the Fire, to have a Mechanical Mixture proceed, or at least accede during the Fusion itself: Which is done here by pounding Glass of Lead mixt with the Ore. But if you think that your Glass of Lead is not sufficiently fusible, you may add to it Litharge melted first, and then pounded into a fine Powder.

2. As this Scorification requires a longer and greater Fire than the foregoing, and as a greater Quantity of Litharge is moreover requisite, to subdue the refractory Scoria; it is easy to see, why a much greater Quantity of Lead must be used here, than in Process I. And though less Lead is often sufficient; it is nevertheless proper always to use the greatest Quantity that can be necessary; lest, for Instance, it should be necessary to try so many Times the Lead alone; to make it evident, how much Silver, the Lead, when alone, leaves (Proc. II. No. 5.) in the Coppel. Nor need you fear, lest any Thing of the Silver may be taken away by the Lead; provided the Coppels be good, and the Coppelling duly put in Execution; for you can hardly collect a ponderable Quantity of Silver, out of the collected Fume of the Lead, which rises during the Coppelling, as well as out of the Litharge that is withdrawn into the Coppel.

3. If it happens that the Scoria grows clammy, and adheres to the Sides of the Vessel to such a Degree, as that it can hardly be poured out, and thus retains something of the *Regulus*: Some, in this Case, are used to add Coal-Dust, or the *Caput Mor-*

tuum of *Aqua Fortis*, or of *Vitriol*; and to pour it out soon after: But this is necessary upon no Account, when an exact Mixture of Glass of Lead is made with the Ore, after the Manner just mentioned, and a proper Regimen of the Fire observed.

PROCESS IV.

Precipitation with Lead by Scorification, of Silver out of an Ore, rendered refractory by Pyrites (Part I. § 316, 323, 342, 369.)

APPARATUS.

1. **B**reak your Ore into a rough Powder, and put a Centner of it into the Test: Put upon this another Test, in the Manner of a Tile. Put it under the Muffle hardly red hot: Increase the Fire by Degrees: There will always be a crackling: Which being ended, take away the upper-Test; for when the Vessels have been red-hot about one Minute, the Ore ceases to split: Leave the Ore under the Muffle, till the Arsenick and Sulphur are for the most Part evaporated: Which you will know from the Cessation of the visible Smoak, of the Smell of Garlick, or the Acid. Then, take away the Test, and leave it in a Place not too cold, that it may cool of itself.

2. Pour out, without any Dissipation, the roasted Ore, and with a Knife take away what is adherent to the Vessel: Pound it to a most subtil Powder, and grind it together with an equal Weight of Glass of Lead; and finally, scorify the whole collected Ore, in the same Test wherein the roasting was made, unless it has contracted Chinks; as was described in (*Proc. III.*)

The Use and Reasons of the Process.

1. Yellow Pyrites-Ores, contain a very great Quantity of Sulphur, even greater than is necessary, to saturate

faturate the Metal that lies hidden in them. For which Reason, this superfluous Sulphur dissipates in a middling Fire: But if it had been mixt with Lead, it would have rendered it refractory; nor could it afterwards be dissipated from it (*Part I. § 142.*) without a considerable Destruction of the Lead. The white arsenical Pyrites, turn also a great Quantity of Lead into Glass, on account of the Abundance of the Arsenick they contain. For which Reason, these Ores must be previously roasted, that the Sulphur and Arsenick may be dissipated: Nor need you fear, lest any Part of the Silver be carried away by the Arsenick: For when Arsenick is separated from any fixt Body, by a certain Degree of Fire; it carries nothing of that Body away with it (*Part I. § 74, 329.*)

2. Every Pyrites has Iron for its Basis: But this is not only refractory of its own Nature, but has much ado to melt into a thin Scoria even with the Glass of Lead.

3. Near a-Kind to these is an unmetallick Earth, annexed in great Plenty (*Part I. § 316, 323.*) to every Pyrites. Therefore, after the Sulphur and Arsenick are dissipated, the only Thing remaining to be done, is, to use the Methods we have described in the third Process.

P R O C E S S V.

Precipitation of Silver out of Iron, by Scorification.

A P P A R A T U S.

1. **P**UT one Centner of Iron reduced to Filings, or to thin Lamina's, into a glass Cucurbite cut off in the Middle, the Belly of which must be luted over; then pour upon it as much Oil of Vitriol, diluted in about eight Times the same Quantity of Water, as is required for the Dissolution of Iron: Put the Cucurbite again upon the Ashes or a warm Bed

Bed of Sand; that the Dissolution may be made by a gentle Heat: This being perfect, put burning Coals under it, that the boiling Dissolution may thicken by Degrees; till the remaining Mass be intirely dry, of an ash-Colour, and hard: When you see it so, then urge the Fire, till the Vessel grows red-hot: Thus will the Oil of Vitriol be for the greatest Part dissipated: But there will remain at the Bottom a pulverulent, dark red *Caput Mortuum*, which must be taken out of the Vessel, without losing any Thing of it.

2. Divide this into two equal Parts, and grind each of them severally with a Centner of Glass of Lead: Put any one of these Mixtures, together with eight Centners of granulated Lead, into a Test, and compleat the Scorification, in the Manner described in the third Process.

3. Burn off the remaining *Regulus's* separately in two Coppels, according to the second Process, and weigh the remaining Beads of Silver: They will be both of equal Weight. Then substract the Silver proceeding from the Lead added: And thus you will know, how much Silver may be fetched out of a Centner of Iron.

Another Method.

1. Put one Centner of comminuted Iron, and two Centners of crude Antimony, into a small Crucible, and close it with a Tile, and then put it into a strong Fire, that it may melt: When it has been in a perfect State of Fusion for five or eight Minutes, take it out, that it may cool.

2. Break the Crucible when grown cold: You will find Scoria's at Top, and a *Regulus* underneath: Throw the first away, and pound the *Regulus* to a fine Powder, and scorify it with twelve Centners of Lead, upon a continual, though not over-strong Fire; till you see the Lead quite covered with Scoria's: Then pour it out into a Funnel; nor are you

to take so much Notice of the Scoria's, as of the *Regulus*; which must be tough, and of a light Lead-Colour within and without. If it proves blackish and brittle, it then is not fixt yet to be put into the Coppel, but it must be put into the Test a second Time, and the Scorification be repeated: Thus will all the Antimony be at last consumed.

3. Let the Coppelling be performed, as in the second Process.

The Use and Reasons of the Process.

1. Iron, in its metallick State, yields neither to Lead nor to Glass of Lead. But when it is destroyed by the Privation of its Phlogiston, and disposed for a Vitrification, it is easily dissolved by the Scoria or the Glass of Lead; and melts together with it into a thinly fluid black Glass. He therefore that attempts a Scorification, must previously pound this Glass very fine, because this promotes very much the Dissipation of the Phlogiston; which is easily obtained by acid Spirits dissolving Iron; but most perfectly by Oil of Vitriol: For this deprives Iron of Part of its Phlogiston, during the Solution itself: As we may see from the inflammable Spirit that rushes out, and is produced in the actual Solution not only of Iron, but also of Copper and Zink. The same Comminution and Destruction of Iron, is also performed with Sulphur, if this is mixt with Filings of Iron, and melted first in a close Test by a gentle Heat, and finally burnt intirely in a stronger Fire: But the Dissolution is never made so perfect thus, as by the first Methods: For the Sulphur is much sooner burnt, before it can sufficiently penetrate the Iron. Sulphur poured upon red-hot Filings, dissolves them indeed; but then it can hardly be taken out of the Vessels; on which Account it is not rendered so proper for a Scorification, as by the first Method, unless it be beaten small and roasted a second Time: The very same Operation is much better performed with a yellow,

low, sulphureous Pyrites, which hath been thoroughly proved to be destitute of Silver; if it is ground together with an equal Weight of Filings of Iron; and exposed to the Fire, in the same Manner as was said about Sulphur. The Sulphur, however fixt in the Pyrites, requires a great Fire to be expelled; and by Means of that Heat penetrates and dissolves the Body of the Iron at the same Time, till at last, the Fire being made still greater, it is intirely dissipated. But this Method has the Inconveniency, that the Mass of the destroyed Iron is greatly increased, and rendered more refractory by the unmetallick Earth of the Pyrites: Wherefore the prescribed Quantity of Lead, is not sufficient in this Case; and twelve Centners must be added to each Part.

2. Crude Antimony is the most potent *Menstruum* of Iron, partly on Account of its reguline Substance, and partly because of the mineral Sulphur that constitutes about one quarter Part of it. Therefore, a double Quantity of it, mixt with Filings of Iron, dissolves them soon, in a middling melting Fire; but then at the same Time the Iron absorbs the Sulphur of the Antimony (*Part I. § 147. Coroll. 3*), and together hinders the Sulphur from getting into the Silver; because Iron is a greater Friend to Sulphur (*Ibid. Coroll 1*): Therefore, Silver with one Part of *Regulus* of Antimony (which both dissolve each other alike) sinks to the Bottom; and it is, as it were, washed clean of the Iron (*Part I. § 467.*) by the said reguline Part. But, that this Precipitation may succeed perfectly, a pretty strong Fire is required, and must be continued for some Time; and it would not be amiss, if a little of the Iron should separate and turn into a *Regulus*. Nor must the *Regulus* be poured out into an Iron-Cone, but must be left in the Crucible, and be taken out of it, by breaking it when grown cold: For so small a Quantity of Scoria, being too soon cooled, would easily retain something of the reguline Part together with the Silver. Therefore, this *Regulus* must be previously

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scorified

scorified with Lead: Because the Coppel cannot bear any *Regulus* of Antimony: For when this is joined with Lead, it splits the Coppels, and often corrodes them to such a Degree, that the whole Inside of them swells like a Sponge. Therefore, after the Scorification, you must have Regard to the *Regulus* alone, to know whether its Brittleness and black Colour, communicated to it by the *Regulus* of Antimony, will require the Repetition of the Operation. But, you are previously to examine, whether the Antimony contains Silver in it: Which may be done intirely by the same Method already described relating to Silver. For the *Regulus* and Silver is precipitated out of crude Antimony by Iron, Copper, Lead, and Tin. But, before this Examination is made, all these Metals must be tried likewise, to know whether any Silver remains of them after the Scorification and the Coppelling, and what Quantity.

3. As Iron is of such Disposition in its Ore, that it turns into Glass, by means of Fire alone, on account of its Want of a pure Phlogiston; it is plain enough, why Iron-Ore is fit to be scorified with Lead, without any previous Dissipation of its Phlogiston: Although it be the only Ore refractory to such a Degree, as not to be brought without great Difficulty to a sufficient Degree of Fusion, unless it be joined to a great Quantity of mineral Sulphur, or Arsenick.

PROCESS VI.

Separation of Silver from Copper, by coppelling.

1. **R**educer the Copper into Filings, or thin Plates, which you must cut into small Bits with a Pair of Sheers: Weigh one Centner, or one Mark, of either; and sixteen times the Weight, with Regard to the Copper, of granulated Lead: Put the latter with a Ladle into a large well-baked Coppel; make a great Fire, and continue it so, till the Lead begins to smoak well and boil: Then add the Cop-

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per wrapt up in a small Paper, so that it may be immersed into the Middle of the boiling Lead: This preserves the Copper, which adheres to the Border, from being difficultly, or even not dissolved at all.

2. When all the Copper is dissolved, suppress the Fire, till you see on the Surface of the just-melted Lead a Smoak wandering here and there, and the metallick Mass not very high nor bright, but low, moderately white, and the Coppel brown, as far as it has been penetrated by the Litharge. However, take Care that the Ebullition of the Lead does not cease intirely: For it is a very good Indication of the Degree of the Fire. If you employ too great a Fire, you will certainly lose some of your Silver; especially, if you are not provided with the best Coppels.

3. When you see the greatest Part of the Metal already consumed, increase the Fire gradually, and make it pretty strong towards the End, that it may burn quite bright and clear. Then take out the Coppel; and if the Operation has been rightly made, you will find the Bead of Silver, if there was any in the Copper, quite bright, and surrounded with bright Scoria's of a yellow Colour, in Form of Crytals. The Coppel is always tinged with a dark Colour. But if you perceive the Grains of Silver, either quite dark, or only the Surface of it tarnished with dark-coloured Scales; it is a Sign, that there is still a great Deal of Copper mixt with it: Which must be attributed to the Defect of the Fire or of the Lead, or to the too late Immersion of the Copper into the boiling Lead: For then, a considerable Part of the Lead being consumed, the remaining Part has not the Power of consuming the Copper sufficiently. But if all the Scoria is intirely vanished, you have used too great a Fire in the Middle and towards the End of the Cop-pelling: In which Case, you must, for the greater Security, repeat the Process.

The Use and Reasons of the Process.

1. Among all Metals, and all the Minerals which are separated from Gold and Silver by Lead, Copper is the only one that remains joined to the residuous *Regulus* of Lead after the Scorification, and is fit to undergo the Coppelling: For the others either are not at all received by Lead; or, if they are, it rejects and destroys them before the Scorification; or, if they remain united with the Lead, they split and corrode the Coppels. The Coppels are also easily split, especially the larger Ones, when you put Lead into them before they are quite red-hot.

2. The Scoria which is produced during this Process is indeed that common Litharge, which is sold: It is a Texture of small scaly Lamina's looking like Glimmer, and if you break it, it resists like other Litharge, by a certain Toughness.

3. There is no Metal but Copper alone, that melts together with Lead into one Mass, and dies the Coppels with a blackish Colour. Therefore, when you see this, you may safely conclude, that there is Copper in the Lead.

P R O C E S S VII.

Precipitation of Silver out of Tin, by Scorification.

A P P A R A T U S.

1. **D**ivide one single Centner of Tin into two equal Parts: Put each of them into a separate Test, and add to each sixteen Centners of granulated Lead, and one of Copper: Put the whole under the Muffle, and make a very strong Fire: The Tin will be calcined immediately, and swim upon the Lead (*Part I. § 41.*)

2. Then diminish the Fire a little; till the Ashes of the Tin that swim at Top, do no longer sparkle:
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When you see this, add with a Ladle two Centners of Glafs of Lead into each Test; in such Manner, that it may be spread wide, through the whole Surface of the rejected Calx. Thus the Calx of the Tin is so much involved and penetrated by the Glafs of Lead, that at last it changes its Form of a Powder, into the tenacious Form of Glafs. If you perceive this, increase the Fire to its highest Degree; stir up the Scoria's with a warm Poker, and when you have seen the Signs of a compleated Scorification, pour out the Mass; and for the rest, observe here the same Things, which we prescribed in the third Process.

3. The Scoria's being separated, put both *Regulus's* into two Coppels well heated; and put into a third Coppel sixteen Centners of Lead, and one Centner of the same Copper which you have used for the Scorification (N^o 1.) of Tin; that you may be able to determine, how much Silver, Copper, and Lead, these Quantities contain, which must be afterwards substracted (*Proc.* II. N^o 5). For if you neglect to do this, you cannot be sure of having separated the Silver from the Tin. Let the Regimen of the Fire be the same during the Coppelling, as in the sixth Process. But the other two first *Regulus's*, must weigh the same in the Balance: If not, the Process must be repeated.

Another Method.

1. Reduce your Tin into thin Lamina's or into Filings; or, if it is brittle, pound it to a fine Powder: Then put two half Centners of it into two separate Tests; put them under the Muffle, and make a middling Fire, that they may turn to Ashes: Then take out the Tests: Mix with each Part of the Ashes two Centners of Glafs of Lead, and then put each separate Mixture with twelve Centners of Lead into the same Tests, and perform the Scorification in the same Manner as in the third Process. But make the

PELLING according to the second Process. And thus will the Operation proceed without Copper.

2. The Calcination of Tin is more speedily performed, if you put into the Test half a Centner of Tin upon twelve Centners of Lead, and lay it on the fore-Part of the Muffle that is less hot: For then the Tin will be perfectly calcined in a few Minutes. Then take out the Vessels; let them grow cold, that the Ashes may be collected; mix them with Glass of Lead, and, finally, scorify them upon the same Lead and in the same Test, as before (N^o 1.)

The Use and Reasons of the Process.

1. The first Method by which the Scorification is performed with Copper, is more speedy than the foregoing: But, on account of the Copper added, you must not only add an enormous Quantity of Lead, because Copper requires sixteen Times the Quantity of Lead to be destroyed (see the sixth Process), but you must besides examine also separately in a Coppel, whether the Copper contains any Silver. The two last Methods are cleverer; but they can hardly be perfectly executed in two Hours: Because the Scoria of Tin, without adding Copper to it, is with great Difficulty brought to the same Degree of Perfection, as when Copper is added.

P R O C E S S VIII.

To examine the Allay of Silver with Copper, by Coppelling.

A P P A R A T U S.

1. **R**UB the Metal upon the Touch-stone well wiped, and compare the Proof-Needles; to know nearly what the Proportion of the Mixture is, and of Course how much Lead must be added, to consume all the Copper: But as the Lead necessary for

or the consuming of the Copper, is not in a Quantity proportionable to that of the Copper, when his is mixt with Silver; we shall here indicate the Quantity to be added in every Case which was prescribed by *Erker*; though some others differ very much from him. But we shall take for our Example a Series of Needles, made according to the Mark divided into half-Ounces and Grains (*Part I. § 290*).

$\frac{1}{2}$ Ounce. Sil. $\frac{1}{2}$ Ounce. Copp. Marks of Lead to be added.

15	$\frac{1}{2}$	—	$\frac{1}{2}$	—	4			
15	—	—	1	—	6			
14	—	—	2	—	8			
12 & 13	—	4 & 3	—	—	10			
9	—	12	—	7	—	4	—	14
4	—	8	—	12	—	8	—	15
1	—	4	—	15	—	12	—	16

Every Body may easily reduce this Table to the Needles made according to the Mark of the Avoirdupois, or that of Karats: Nor is it necessary to proportion the Quantities of Lead to be added, so far as one half-Centner.

2. In the mean Time, let the Metal to be tried with the Needles, undergo the Operation of Coppelling, together with the Quantity of Lead indicated (N^o 1), as in the sixth Process. Only you are to observe concerning the Regimen of the Fire, that you must make it the gentler, as the Silver is allayed with a greater Quantity of Copper; and on the contrary, the smaller the Quantity of the Allay of Copper is, the stronger must be the Fire to be used in the Operation. As for the rest, all we have said in the sixth Process doth likewise belong to this.

The Use and Reasons of the Process.

1. Pure Copper, in whatsoever Quantity, is intirely consumed by sixteen Times as much Lead. But it is quite otherwise, when it is mixt with Silver: For Copper is the more defended by the Silver, in Proportion as it is in lesser Quantity mixt with Silver, and *vice versa*. For Instance, half an Ounce of Copper is consumed in the Coppel by sixteen half-Ounces of Lead: But if one half-Ounce of Copper is confounded in the Fire, with eight half-Ounces of Silver, sixteen half-Ounces of Lead will never suffice, to destroy the whole half-Ounce of Copper. Now, if you have found out by Experiment, the least Quantity of Lead that is sufficient, and repeat the Experiment anew, with half an Ounce of Copper mixt with sixteen half-Ounces of Silver; you will see, that the same Quantity of Lead, which in the first Case had the Power of compleating the Purification of the Silver, is by no means sufficient, to convert the whole Copper into Scoria; and that some more Lead must be added: and so on.

2. Thence you may derive the Reason why Silver cannot be intirely freed from all Copper by copelling? Besides, you will never buy any Lead, that is altogether void of Copper: For you will find in no Place any Heap of the purest Lead-Ores, that are not slightly mixt with Copper-Ore, or Pyrites. Now, the perfect Separation of such a small Quantity of Copper, which is indeed very difficult, would never repay the Charges of it; wherefore, it remains in the Lead, after this is melted out of the Ore. Therefore, whatsoever Quantity of Lead you may use for the Purifying of Silver from Copper, there remains always some minute Quantity of the Latter adherent to the Former: And as Copper is the more difficultly separated from Silver by Lead, as the Proportion of the Copper with Regard to the Silver diminishes; for this Reason, a greater Excess of Lead
is

is required with Regard to this residuous Copper, than is necessary, even in the Lead itself, with Regard to the Copper mixt to it. He therefore who attempts the most intimate Depuration of Silver by coppelling, must previously render the Lead perfectly pure from all Copper: of which hereafter.

PROCESS IX.

To precipitate Silver out of its Ore, by coppelling alone.

APPARATUS.

1. **P**ound one Centner of the Ore; roast it (*Proc. IV. N^o. I.*); when roasted, beat it to a most subtil Powder; and, if it melts with Difficulty on the Fire, grind it together with one Centner of Litharge, which is not necessary, when the Ore melts easily. Then divide the Mixture, or the Powder of the Ore alone, into five or six Parts, and wrap up every one of them severally, in such Bits of Paper as can contain no more than this small Portion.

2. Put a very large Coppel under the Muffle: Roast it well first, and then put into it sixteen Centners of Lead: When the Lead begins to smoak and boil, put upon it one of the said (N^o. I.) Portions with the small Paper it was wrapt up in, and diminish the Fire immediately, in the same Manner as if you would make a Scorification in a Test, but in a lesser Space of Time. The small Paper, which turns presently to Ashes, goes off of itself, and does not sensibly increase the Mass of the Scoria's: The Ore proceeding therefrom, is cast on the Border, and turns to Scoria's very soon. Increase the Fire again immediately, and at the same Time put another Portion of the Ore into the Coppel, as was just now said: The same Effects will be produced. Go on in the same Manner, till all the Portions are thrown in, and consumed in the Lead. Finally, destroy the remaining Lead with a stronger Fire.

3. The

3. The Silver that was in the Ore and the Lead, will remain in the Coppel: If you take out of it the Bead proceeding from the Lead, you will have the Weight of the Silver contained in the Ore. If the Ore employed was easy to be melted, all the Scoria vanishes; but if it was refractory or not fusible, all the Scoria does not always go away; but there remains now and then something of it in the Form of Dust. A great many Ores and Metals may be tried in this Manner, except only such as split and corrode the Coppels: There are likewise some of them, which must be previously prepared, in the same Manner as is required, to render them fit for going through a Scorification. See all the foregoing Processes.

The Use and Reasons of the Process.

1. The Ore thrown at several Times upon Lead boiling in a Coppel, may be dissolved without the foregoing Scorification. But this is very far from having an equal Success with all Kinds of Ores: For there are Ores and Metals which resist very much to their Dissolution by Litharge; and which being on this Account thrown on the Border are not sufficiently dissolved; because the Litharge steals soon away into the Coppel. Nevertheless, there are some others, which vanish intirely by this Method, except the Silver and Gold that was contained in them.

2. A previous Roasting is necessary, first for the Reasons mentioned (*Proc. IV. Uf. N°. 1.*) and then because the Ore thrown upon boiling Lead, should not crackle and leap out: For, having once passed the Fire, it bears the most sudden Heat.

3. Though this Method requires no previous Scorification, you are not to conclude from thence, that it is the same with the Operation by which Metallurgists separate Silver from its Ores: For in these Cases a Scorification is always previously made: For which Reason

Reason these two Operations are not always attended with the same Effects.

PROCESS X.

The purifying of Silver by Lead, in a large Test, by the Blast of Bellows.

APPARATUS.

1. **P**UT into a large Test made in an earthen Pot (*Part I. Plat. I. Fig. II.*) and dried beforehand in a warm Place, red burning Coals, till it is thoroughly dry, and quite burning hot: Then make a Hole in the Hearth of the Smith's Forge, fit to receive the Pot with its Test, and fill it with Ashes, to such a Height as that the Border of the Test put into it may be as high as the Hearth of the Forge. Place the Pot in a horizontal Situation, and fill the Space between the Test and the Cavity of the Hole, with Ashes well pressed down, lest they should be easily blown away. Then dispose the Noſel of the Bellows in such a Manner, that, blowing obliquely downwards, it may play strongly upon the Cavity of the Test: And this you will know to be well done, if the Wind proceeding from thence, dissipates the Ashes fallen into the Test.

2. Put into the hollow of the Test, so much Straw, Paper, Linen, or worn-out Cloth, as is necessary to hinder the Surface of it from being damaged by the Silver to be put into it: Put your Silver thereupon, and cover it well all over with red burning Coals: Then excite the Fire with the Bellows, till the Silver melts: This done, remove towards the Border the Coals hitherto kept in the Middle of the Test. Add next some new Wood and Coals, especially towards the Bellows; and place the Coals all round in plenty, provided they do not intercept the Sight of the Mass in Fusion: And, mean while, continue to make a strong Fire with the Blast of the Bellows.

3. Then

3. Then add at several Times some Lead reduced into small Globules of a determined Weight: The same Phenomena will appear, that were mentioned (*Proc. II*). Go on with adding some Lead, and then diminish the Fire a little, which must not be greater than is necessary to keep the Silver in Fusion: Continue thus, till the Silver is rendered quite pure: Which may be guessed nearly, from the Examination previously made of its Purity or Impurity, by the Needle or by a docimastical Trial; and from the already-consumed Quantity of Lead, that was judged necessary for the Purifying of it. However, you will be more sure of this; if, the Lead being consumed, you thrust a moist Iron-Wire into the melted Silver, and look upon what adheres to it, the Instant it is fetched out, to see whether it is become yellow, or white, polished, and malleable: If not, more Lead must be added. The melted Silver must be stirred sometimes with a crooked Iron (*Part I. Plat. IV. Fig. IX*), towards the End; that the Lead, possibly adhering underneath, may be intirely consumed.

4. The Operation being finished, pour Water, Drop by Drop, or with a small Stream, upon the melted Mass; that the Silver may grow solid. When it is so, take it out of the Test with a Wedge, rub off all the Filth and Ashes adherent to it, with a Brass-Brush made of small Brass Wires collected into a small Bundle, pouring in the mean Time constantly some Water upon the Silver.

The Use and Reasons of the Process.

1. Take Care in this Process, that the Fire be not continued too strong: For by that Means the Tests grow soft, and a great Deal of the Silver is lost. For the same Purpose, the Test must be put into the Pit, and surrounded on all Sides with Ashes; whereby you hinder at the same Time the Pot that contains the Test, from splitting and falling down, and all the

Silver

Silver from being spilled, if the Test should at the same Time contract a large Crack.

2. If you add the Lead at several Times, the purifying of the Silver may be performed, with a much less Quantity of it, than that indicated in the eighth Process. However, though, in this Operation, the Silver be found pure at Top; nevertheless, Part of the Lead, which is heavier; commonly hides itself underneath (*Proc. II. Uf. N^o. 3*), unless the Mass in Fusion be now and then stirred with a Piece of Iron, towards the End. But the same Inconvenience may be prevented in the small Tests or Coppels, if you strike these little Vessels with an Iron-Wire, while the Silver is still in Fusion, that this being melted may be shaken. Whence it plainly appears, that Silver and Lead mixt only by Fire, are not so well mixt to each other, as that a perfectly proportionable Quantity of both may be found in any Part of the Mixture whatever: Which, being either unknown to or neglected by Artificers, deceives them very often.

3. By this Method, a considerable Quantity of Silver may be purified at one and the same Time: But if a very refractory Scoria is produced, for Instance by a Mixture of Tin, it must now and then be sunk to the Bottom with a Poker, that the Silver may be washed off from it: And thus cast on the Border of the Test. But it is proper afterwards to examine such a Scoria, to see whether it has not carried away with it, a Quantity of Silver deserving the Charges of a Separation.

4. The Lead may again be reduced out of the Tests employed in this Operation; nay, this Lead is not even without some Silver; especially if the Tests were not good, or the Operations not exactly made: But then it will be proper again to use the same Lead for a like Operation; that the Silver may at last be separated from it.

PROCESS XI.

The purifying of Silver in a large Test, under the Muffle.

APPARATUS.

1. **P**UT the Tin inclosed in an Iron-Ring (*Part I. Plat. I. Fig. VIII*), into the Furnace represented (*Part I. Plat. IV*), as you may very well understand, from the several Figures of the Furnace and from the Description given of them. When the Test has been red-hot in a strong Fire for about half an Hour; put into it the Silver wrapt up in Bits of Cloth or of Paper, and divided into several Portions: Fill the Orifice of the Furnace with red burning Coals, which must be kindled with a Pair of hand-Bellows, till the Silver is in Fusion.

2. This done add some Lead; diminish the Fire a little: And do the rest as has been prescribed in the foregoing Process.

The Use and Reasons of the Process.

1. The purifying of Silver is made in a much neater Manner, by this Method than by the foregoing: And as the Regimen of the Fire may be observed here with great Exactness, so the Silver is purified with a less considerable Loss: For which Reason it is always preferred to the foregoing, when you are to purify Silver mixt with a great Deal of Copper: But it is a very long Operation.

2. When you are to purify only a few Ounces, of one single Mark of Silver; you may put such a small Apparatus into the docimaistical (*Part I. Plat. III. Fig. I.*) Furnace.

PROCESS XII.

A Method to select Specimens out of Metals that have been refined, as well as out of those that are melted together with Sulphur and Arsenick, that there may be the same Proportion of the Mixtures in the latter, as there is in the former.

WE have, in the foregoing Process, explained in what Manner Silver, together with the Gold that lies hidden therein, may be separated from foreign Bodies: But you cannot conclude otherwise than hypothetically from these Processes, how much Silver and Gold may be fetched, out of a greater Quantity of the same Matter, from which you have taken your Specimen for the docimastical Trial: For Instance, whether there is the same Proportion of Ingredients in a separate Specimen, as in the whole Mass to be tried. But such an equal Union is not always met with, in pure Metals confounded together by the Fire: Which we have seen plainly (*Proc. X. Uf. N^o. 2*); where Silver melted with Lead, and left to itself, was not evenly dissolved by the Lead, but the same Portion of the Mixture contained more Silver at Top, and less underneath, and Lead in an inverted Proportion. The same Thing happens likewise with Gold and Lead, and with Copper and Lead: Unless you have Recourse to some other manual Operation besides the Fire, in order to obtain a more perfect Mixture. Besides, it also depends much from the greater or less Degree of the Fire; which may increase, diminish, or totally disturb, the Action of the *Menstrua*. Nay, the Mixture of some Metals, for Instance of Gold, Silver, and Copper, which easily dissolve each other equally, is so much troubled by the Addition of some other Metal, for Instance of Lead; that an equal Proportion of the Metals is no longer preserved in every Part of the Mass: For Gold and Silver, yielding
more

more to Lead than to Copper, sink to the Bottom in Company with it; so that the Mixture is much richer in Gold, Silver, and Lead there, than in the Middle, and at the upper Surface. But if Sulphur and Arsenick are joined to the Mixtures of Metals, they cannot but make a great Alteration there: For as they both dissolve one Metal more greedily than another; they not only render the Mixture unequal, but sometimes destroy it intirely: So that a Metal dissolved by them, becoming lighter, it swims at Top like Scoria's, while the other Part of the Mixture sinks towards the Bottom, by its Gravity.

A P P A R A T U S.

1. When Ores grossly melted, are collected into brittle *Regulus's* in the Beds of the Furnaces, you are to proceed in the following Manner. With a Hammer and a Wedge, separate from the *Regulus* two Pieces of equal Weight, for Instance of half an Ounce; that is, one in the Middle of the upper Surface, between the Centner and the Circumference; and the other in the inferior Surface of the *Regulus*, but on the opposite Side. Beat both to a fine Powder, of which weigh a Centner, and, as Sulphur, Arsenick, Iron, and a Portion of unmetallick Earth are not wanting therein, proceed according to *Proc. IV.*

But when you have a Mind to examine a greater Number of *Regulus's*, together in one and the same Trial, cut off Bits from each *Regulus*, in the Manner mentioned: you need only take Care, that the Weights of the Bits cut off be nearly proportioned to the Weights of the *Regulus's*: Beat them all into a fine Powder, and do the rest as before.

2. But, when you are to examine *Regulus's* that are not brittle; Bits must likewise be cut off, in the Manner just (N^o. 1.) mentioned: But, when cut, and weighed exactly, you must put them altogether into a new Crucible, well rubbed with Soap within, and melt them: When they are well melted, stir them
immediately

immediately with a dry Stick half-burnt; that they may all be well mixt together: Leave them so for about one Minute; then stir them again for the last Time, and throw into them a small Bit of Paper folded up, and rubbed with Wax or Tallow: And while it burns with a clear Flame, pour the whole Mass at one Stream into the Moulds (*Part I. Plat. II. Fig. XX*), placed quite horizontal, and rubbed with Tallow; and let this grow cold of itself, together with the Mass therein contained. But the Mass taken afterwards out of the Moulds, and commonly called *Ingot*, as is also the Cone itself (*Part I. § 223*), must be smooth, solid, and of an equal Thickness all round: But if it appears rough, and the Inside of the Crucible (as far as the Mass has touched it during the melting and the pouring out) is seen covered with a metallick Skin, it is a Sign that the Fire has been defective: And consequently an equal Mixture has not been obtained. Besides, a Fire too great and continued too long, produces a Scoria sometimes solid, sometimes spongy, full of Bubbles, covering the Mass here and there when it has been poured out and cooled, or insinuating itself deeper into it, while it is pouring out: If this be the Case, the Process must be repeated. If the Mass is in good Condition, scour it well with Coal-Dust, and weigh it, to know how much of its Substance has been lost. Then cut off from it a Bit, in the Place which is distant one quarter Part of the Length of the whole Mass from each Extremity, in such Manner however, that the Mass may at the same Time be divided by a transversal Section. This done, subtract as much from the Centner or docimaistical Mark, as all the Specimens cut off from the *Regulus's*, and weighed together before the Fusion, have lost of their Weight: Let the rest go for an intire Centner or docimaistical Mark, and with a File make the Specimen, which you have cut off from the Mass of the Ingot, equal to it. However, take care not to scrape off any Thing from another Place, except from the two Sur-

faces which have been formed by the transversal Section; especially if there is any Lead in it. The Scorification is made as in *Proc. III*, but without Lead-Glass. Nevertheless, if an imperfect and refractory Scoria is produced, pour upon it a little of Lead-Glass, to subdue it. Let the remaining *Regulus* go through the Operation of coppelling, as in *Proc. II*, or, if there is any Copper, as in *Proc. VI*.

3. By these Precautions (N^o. 1, 2) all the Silver and Gold remaining out of the Test, or reduced into the Form of Tables, may and ought to be cut off and prepared for a Trial: However, it is not always necessary to begin by a Scorification; unless Iron, Tin, &c. are mixt to the Mass: We have already shewed the Manner of managing them.

4. When Coins are to be tried, you must cut off a small Bit from them along your Diameter, and with a File reduce it to the Weight of the Mark, in the same Manner as the small Bit cut off from the Mass of the Ingot.

5. But when Coins of different Kinds, and old Utensils, that have been coloured by having been boiled, are to be examined, the Thing is hardly done with more Ease and Security, than if all these Metals are granulated (*Part I. § 216, 217.*) together.

The Use and Reasons of the Process.

1. There is almost a greater Care required, in the Choice of these Specimens, than in the Operation itself, by which Gold and Silver are separated from the other Minerals. Great Errors may be committed, when an Ingot is to be melted out of the small Masses cut off. For Sulphur, Arsenick, Copper, Lead, and all the other Minerals, evaporate in Part, when the Fire is too strong and too long kept, and partly turn to Scoria's, while the more fixt Part of the Silver and Gold remains: For this Reason, the Proportion which ought to have been preserved in the remaining Ingot, is taken away: Whence it happens,

pens, that the Examination indicates a greater Quantity of Silver and Gold, than the Mixture out of which the Specimens have been taken, does in Reality contain. But this may be avoided, if you substract that Part, which the Specimens taken together have lost in the Fire, from the Centner or docimaistical Mark: That the remaining Part may be taken for the whole: Thus the Silver and Gold remaining after the Operation, will perfectly answer to the Quantity contained in the whole Mass of the Mixture.

2. When Lead enters into the Mixture together with Copper, the Ingot ought never to be extinguished with Water: For the Copper growing cold on a sudden in Water, contracts, and repels the Lead still in Fusion towards the Outside, and towards that Part of the Ingot which is immersed the last into the Water. Likewise, the Ingot is always richer in Silver and Gold, in the Place where the Cone has been inclined towards the Horizon, than it is in the opposite Extremity: Which is especially true of those Mixtures, in which Lead and Copper enter together. The Reason of this is self-evident, from what has been said at the Beginning of this Process. But the Copper must be tried before it is roasted, to see whether it contains Silver, or Gold: For after that, their Separation is hardly worth the Charges (*Part I. § 468, 469.*)

3. Old Utensils and Coins may be very well tried, if previously granulated. For when the Boiling happens to render them white, or when the Metal with which the Allay has been made, is not mixt in an even Manner, you are infallibly deceived. Now, they are rendered white by all such Bodies, as corrode Copper the moist Way, and leave the Silver untouched. When such Silver is allay'd with Copper, you must first wipe it very well, or make it slightly red in the Fire; that the fat Filthiness may be dissipated. Then put it into a Brass-Kettle tinned over, and pour upon it enough of tartish Small-Beer, or of Water, that the

Silver may be intirely immersed: Then throw into the Liquor a Quantity of Sea-Salt, and Tartar: Put the whole together upon the Fire, and make it boil: Thus will the Copper be eroded from the Surface in a few Hours, and the Silver remain alone. Therefore, though you had put the most polished Lamina into the Fire, you will take it out quite destitute of Brightness, but of the whitest Colour. Then wash it with Small-Beer, and rub the Surface of the Silver, with Brushes made of thin Brass-Wires. But if this Surface is again rubbed with a smooth Piece of Steel, it recovers its former Polishing. It is here necessary to know this deceitful Colour, not only when you use the (*Part I. § 300.*) Touch-stone, but also in a docimastical Trial: For when the Specimen taken off from such Silver, is thin, or of a large Surface, it leaves more Silver in the Coppel, than if you cut from that Silver a small Bit of the same Weight, in a Place where a lesser Surface has been contiguous to the corroding Solution.

PROCESS XIII.

The washing (Part I. § 337, 479.) of an Ore, rendered difficult to be melted, by Earths and Stones.

APPARATUS.

I. **B**REAK your Ore in an Iron-Mortar, to a Powder not very fine: Weigh twenty or thirty docimastical Centners of it, in a large Balance: Put them into a washing Trough (*Part I. Plat. II. Fig. XVI.*) pour some Water upon them, that the Powder of the Ore may be thoroughly moist: Then have a Vessel full of Water, the Diaméter of which must be a little larger than the Length of the Trough: Take the Trough with your left-Hand, at the Top of the hinder-Part, and dip it horizontally into the Water, and move it gently with your right-Hand, from the fore-Part of the Trough, which is less deep, towards

towards the hinder Part, which is deeper: Then take out the Trough, and incline it a little on the fore-Part; that the Water may run out, and the heavier metallick Part remain at the Bottom: Repeat this several Times over, till the Ore remains quite pure.

2. If the Ore is inherent to a very hard Stone hardly yielding to Iron, such as are Flints, and the other Stones of that Kind, or to a ponderous, calcareous, Spaad-like Stone; it must first be weighed, and then be made quite red-hot in a Crucible, and in this Condition be thrown into a Vessel full of cold Water, and after that be pounded very fine and washed very clean.

3. When the Ore is washed, weigh it, and try one Centner of it: that is, according as the Nature of the Ore requires it. Thus you will easily compute, how much Silver or Gold, you will be able to obtain from twenty Centners of Ore.

The Use and Reasons of the Process.

1. From what has been just said, and from what was said (*Part I.* § 338) it appears, that every Ore will not bear washing; it shews likewise what kind of washing each Ore will require; and what Ores can be washed without a Preparation: Of this last Kind are those which consist of solid pure Particles, and lie hidden in a soft fat kind of Earth, or in Sand. Thence, you likewise see, in what Manner they must be previously pounded, or calcined (*Compare Part I.* § 337). By Calcination, you not only break Stones into Pieces with greater Facility, but Ores besides melt into solider Masses, which most commonly are specifically heavier, on account of the Sulphur and Arsenick in a Manner dispersed through them.

2. The Intention of washing is, to render the Ore more tractable in the Fire; and to hinder the metallick Parts from being difficultly precipitated, or even totally detained by so great a Mass of Scoria's,

and that a much greater Quantity of Ore may be fluxed in the same Fire, and in the same Time.

3. But the lightest Powder washed off, must sometimes be tried: For it now and then happens, that the Water carries away a greater Quantity of Ore, than there remains of it in the Bottom of the Vessel: In which the most experienced People are oftentimes deceived. Nay, the Waters which run by Veins of Ores, commonly enough carry Part of them away, and after having dragged it a long Way together with them, at last let it fall at the Bottom of the Channel. As for the rest, see *G. Agric. de re Met. Lib. VIII.*

P R O C E S S XIV.

The purifying of Silver with Nitre.

A P P A R A T U S.

1. **R**Educe your Silver to Grains, or Plates; put them into a Crucible: Add about one-quarter Part of the driest Nitre pulverized. Put upon this Crucible another of a lesser Size, having at its Bottom a Hole about as large as a Pea, in an inverted Situation, that the Border of it may be received into the Orifice of the other. Shut up the Joint of the two Crucibles, with a Lute that may bear the Fire; And when this is dry, put the Crucibles in a wind-Furnace, and surround them with Charcoals, to the Height of the Bottom of the upper Crucible, and not further.

2. Then light the Fire at Top, and increase it till the Vessels are middling red-hot. Then with a Pair of Tongs take a burning Coal, and hold it at one Finger's distance directly above the Hole at the Bottom of the upper Crucible: If you see a sudden clear Light produced near and about the Coal, together with a crackling Noise, this shews that the Fire has actually the requisite Degree of Strength: But if this either does not appear at all, or only very faintly,
the

the Fire must be increased. If, on the contrary, you hear a violent Blast of Air, coming forth with a loud crackling Noise, though you have not put the above-mentioned Coal at Top, the Fire is too violent, and must of course be diminished. Which being neglected, you will not only suffer a great Loss of Silver; but large Vessels, charged with a great Quantity of Nitre, now and then burst asunder with Violence and Danger.

3. When this Phenomenon is over, increase the Fire as much as is necessary to make the Silver melt without any Addition: Take the Vessels out of the Fire: Break the under one, when it is grown cold: You will find the *Regulus* of Silver at Bottom, and alkaline Scoria's (commonly green) at Top. If the Silver is not yet sufficiently purified, or too rigid still, put it into another Crucible, and this thus open into a wind-Furnace, throw upon it a little Nitre, and as soon as it melts, pour it into a Mould for Ingots: Thus it will be purified of every thing that's not Gold.

The Use and Reasons of the Process.

1. We have already considered (*Part I. § 137, 161.*) the Action of Nitre upon Metals and Semi-Metals. Therefore, if you operate in a due Manner, Silver is, by this Method, rendered perfectly pure and easy to be bent. But if your Silver is very impure, a small Matter of it is destroyed in this Operation; which must be ascribed to the strong Detonation of Nitre with other Metals, and to the Clamminess of the Scoria's made by their Calxs.

2. The Nitre in this Process seems partly to become volatile, and partly to change into a fixt Alkali, so very pure, that there remains not the least Footstep of Nitre: For when you pour upon it Oil of Vitriol, it does not in the least excite the unpleasant Smell of *Aqua Fortis*, which nevertheless is commonly produced, when you prepare fixt Nitre in the usual

Manner: The Reason of this Diversity is, that they do not imploy a Fire sufficiently strong, to consume or dissipate all Sorts of Nitre.

3. Silver thus purified for the first Time, has always in it a small Quantity of heterogeneous Metal: But if you melt it a second Time (N^o. 3.) with Nitre, and pour it out, the Moment it is in Fusion, you free it of that Residue, and render it very easy to be bent. But your Silver will not acquire so great a Degree of Purity and Pliantness, unless you pour it out the very Instant it is in Fusion. For the Nitre, when left too long in the Fire, dissipates, or changes: And when this happens, the Metals calcined by the Nitre, though in ever so small a Quantity, are reduced by the fat Exhalations of the Coals, and much more still when the Coals themselves fall into them: Nor is the residuous alkaline Salt an Obstacle, but rather a Help to this. And as Gold, above all, is rendered very rigid, or even quite brittle, by the least Quantity of Tin, Regulus of Antimony, &c. the Reason is plain, why unskilful Artificers, try ten Times and more, to render Gold pliant by Means of Nitre, before they can obtain it.

P R O C E S S V.

Precipitation of Silver out of the same Bodies as were mentioned in the foregoing Processes by Scorification, in a Crucible.

A P P A R A T U S.

1. **T**HE Body out of which you intend to precipitate Silver, must be previously prepared for a Scorification with its proper Ingredients; of which we have already spoken in the foregoing Process; then in the same Manner, and with the same Quantity of granulated Lead, put it into a Crucible strictly examined, that it be intire, solid, not speckled with black Spots, like the Scoria of Iron, especially at its inferior

inferior Part, and capable of containing three Times as much. Add besides Glass-Gall and common Salt, both very dry, and enough that, when the whole is melted, the Salts may swim at Top, at the Height of about half an Inch.

2. Put the Crucible thus loaded into a Wind-Furnace; shut it close with a Tile; put Coals round it, but not higher than the upper-Border of the Crucible: Then light them with burning Coals, and increase the Fire till the whole melts very thin: Which will be done by a middling Fire, maintained always equal, and never greater; leave it thus for about one Quarter of an Hour, that the Scorification may be perfectly made: Take off the Tile, and stir the Mass with an Iron-Wire, and a little after pour it out into the Mould.

3. When the Regulus is cleaned from Scoria's, try it in a Test by coppelling it.

The Use and Reasons of the Process.

1. The Scorification of any Ore whatever, or of any other Body fetched out of Ores, may indeed be made by this *Apparatus*, as well as in a Test under the Muffle: But it serves chiefly, to the End that a greater Quantity of Metal may sometimes be melted from it with Profit: For you may put many common Pounds of it, at one single Time into the Crucible: But then you need not observe the Proportion of Lead prescribed in the foregoing Process, nay, a Quantity of Lead two or three Times less, is sufficient according to the different Qualities of the Object. But the Mass will certainly be spilt, unless you chuse a very good Crucible. For there is no Vessel charged with Litharge, that can bear a strong Fire having a Draught of Wind, without giving Way through it to the Litharge.

2. You add Glass-Gall and common Salt, that they may forward the Scorification, by swimming at Top. For the refractory Scoria rejected by the Litharge,
and

and adhering between this and the Salts that swim at Top, is soon brought to a Flux; and the Precipitation of the Silver is thereby accelerated. They also in a Manner hinder a small burning Coal, fallen into the Crucible, from setting the Litharge a boiling, which troubles the Operation. For the Litharge or Glass of Lead, especially that which is made without any Addition, so soon as the Phlogiston gets into it, raises into a foamy Mass, consisting of a Multitude of small Bubbles, very difficult to be confined, unless the Phlogiston be entirely consumed, and the Litharge reduced to Lead, which sometimes rises above the Border of the Vessel.

P R O C E S S XVI.

Precipitation by Iron and Lead, of Silver out of a Mixture containing a great Deal of Sulphur.

A P P A R A T U S.

THIS may be done in the same Manner as in the foregoing Process, but much better after the Manner following.

1. If you do not know already, how much Silver lies hidden in the Mixture, you must, for that Purpose, make a Trial, according to the first, the second, or the fourth Process. This done, let the Mixture be melted in a Wind-Furnace on a middling Fire, in a Crucible, having a Capacity two or three Times larger. Then cast upon it at several Times, Iron-Filings, not very rusty, and being one third Part with regard to the Weight of the Silver: In the mean Time increase the Fire: When you see the Iron-Filings quite dissolved by the Sulphur, and melted, pour thereupon an equal Weight of granulated Lead with regard to the Silver, in such a Manner, however, that it may be dispersed all over the whole apparent Surface of the melted Mixture: Then stir it with an Iron-Hook, that all these Things may be thoroughly mixt.

2. Shut

2. Shut the Crucible very close: Increase the Fire still more; and after having left it so for about half a Quarter of an Hour; pour the Mass out into a melting Cone, rubbed with Tallow, and warmed, or into an Iron-Mortar, prepared after the same Manner.

3. When it is grown cold, shake the Matter out: You will find at Top Scoria's to be taken off, and at Bottom a *Regulus*, that will have all the Silver in it, together with the Lead, or at least with Part of it. The *Regulus* may be coppelled in a Test.

4. If you know that there is already the same Quantity of Lead in the Mixture, it is not necessary to add any granulated Lead; but rather to double the Weight of the Iron-Filings.

The Use and Reasons of the Process.

1. All that was said (*Part I. § 147. Coroll. 1, 4.*) is very well and plain. But you must add Lead towards the End; that the Silver which is perhaps still inherent in the Mixture, being quicker dissolved by the Lead, may be precipitated, and sink to the Bottom; or that the Sulphur may be intirely taken away by the Lead (*l. c.*), if it has not been thoroughly destroyed by the Iron. There are also some other Metals, that have the same Effect; but Lead is chosen in this Case, because it is very conveniently separated a second Time from the Silver: For there is always something of the precipitating Metal, that mixes with the Metal to be precipitated; the more so, as the Separation is more exactly done: For who can so exactly determine the Point of Saturation, and the Degree of the Fire?

2. You must not use Filings quite spoiled with Rust: For they have no Virtue for absorbing the Sulphur.

3. The Crucibles, which have served to these Processes, retain a little of the Silver, especially if they are rough at the Inside: For this Reason, the same Crucible, so long as it remains intire, must always serve

serve for the same Operation. But when it breaks to Pieces at last, and the Bits are plunged into the boiling Lead, all the Silver is separated from it: Which Lead must serve for the like Operations, as well as that which is reduced out of larger Tests: Thus all the precious Metal is preserved.

P R O C E S S XVII.

The extracting of Silver, by Amalgamation.

A P P A R A T U S.

1. **W**ASH the Ores, Earths, Stones, and Sand, in which Silver lies hidden in its metallick Form, according to *Proc. XIII.* When washed, infuse them in very four Vinegar, in a wooden or Glass-Vessel perfectly clean: But about a tenth Part of Allum must be first boiled and dissolved in this Vinegar, that the washed Powder may be intirely covered over: Leave them thus for one or two Days and Nights.

2. Decant the Vinegar, and wash the macerated Powder in pure warm Water; till the Water becomes quite insipid, when just poured upon it: Dry the Powder; put it into an Iron-Mortar: Then add Mercury four Times the Quantity of the dried Powder, and with a wooden Pestle, ending in a large round Head, and adapted to the Inside of the Mortar by its Figure and Size, beat the whole, till you see every little Part of the Powder rendered of a blackish Colour by the minute Globules of Mercury mixt to it.

3. Then pour Water thereon, and continue the Trituration for a While: because you thus will wash away the terrestrial Powder and the other heterogeneous Bodies remaining, and because all the Globules of the Mercury, will by that Means be aggregated to the Silver and Gold. Pour out the turbid Water, and add some fresh; then grind the whole again,
till

till all the remaining Powder be washed off at last. Then dry the remaining Amalgama with a Sponge, and by a gentle Heat.

The Use and Reasons of the Process.

1. Amalgamation is chiefly used, when Silver lies hidden in its metallick Form in Stones, Earths, and Sand. But when it is in a State of Ore, the Bodies that concur with it to form the Ore, must be dissipated (*Part I. § 463*): Otherwise, the Amalgamation would not succeed. Therefore a previous Washing must be made, that the other Bodies which cannot be dissolved by the Mercury, may be washed off as much as possible: For, unless this be done, the Mercury cannot act freely upon the Silver: Nay, if the Washing is done afterwards, a great Deal of the Mercury is washed off together with these heterogeneous Bodies. For which Reason, likewise, the Ore is soak'd in Vinegar prepared with Allum, that the terrestrial dusty Bodies, or even the fat Ones, may be wiped off the Surface of the Silver. As for the rest, see *Part I. § 65. and following*. For this Reason, the Mercury sometimes refuses to dissolve the Silver: Which nevertheless is corrected, if the Mercury is rubbed with common Salt and Water, and afterwards washed very clean.

2. If you continue to grind the Amalgama with Water, longer than till you see no more Filth in it; the Water poured upon it will nevertheless be always turbid, and you will lose Part of your Amalgama.

3. They make a particular kind of Mills, in which a great Quantity of Amalgamations are made, and which are well described by *G. Agricola, de re Met. Lib. VIII.*

PROCESS XVIII.

The Separation of Silver from the Amalgama.

APPARATUS.

1. **S** Pread a thin Leather upon a wide earthen or Glass-Vessel, very clean: Fold it up in the Form of a Bag, and pour the Amalgama into it: Then tie the Bag very strongly at Top, that the empty Spaces of the Plaits may not give Passage to any Part of the Mercury. This done, if you compress the Bag by wringing it hard, the major Part of the Mercury will pass through it, and run into the Vessel under it. If you can no longer squeeze any Thing out, open the Bag, and you will find in it a white Paste, which shall be the Silver and the Gold that were in the washt Powder: But there remains about an equal Quantity of Mercury still mixt with them after the Squeezing.

2. Put the remaining Paste into a Glass Retort; and this into an Iron-Pot full of Sand (*Plat. IV. Fig. I.*): Apply to it a Recipient, in which there must be such a Quantity of Water, as that the Orifice of the Neck of the Retort may be immersed into it: Nor is it necessary to close the Joints with Lute. Make under this a strong Fire, till you see the Mercury applying itself by large Drops to the Neck of the Retort, and falling into the Water, with a hissing Noise: But if you hear a Crackling in the Retort, then diminish the Fire a little; and if at last nothing more is distilled by the great Fire, let the Retort grow cool, then take it away, and split it with a Thread dipped in Brimstone, which for this Purpose must be tied about the Middle of the Belly of the Retort, and set on Fire: Then in the Fire with Borax run the remaining Metal into a Mass.

The Use and Reasons of the Process.

1. As Mercury requires a Fire three Times stronger, to be volatilized, than Water does; so when it is resolved into Fumes, it coagulates immediately, if touched by Water; nor are you to be apprehensive lest the least Quantity of it should evaporate in open Vessels, provided the Orifice of the distillatory Vessel is immersed under the Water. You are only to take Care not to immerse it too deep: For in this Case, not only the Neck of the Retort splits easily, but, when the Degree of the Fire is very great at first, and afterwards less, the Water ascends through the Neck of the Retort, and falls into the Belly of it, which, on this Account, splits when it is hot; and thus the Operation is destroyed. But when the Neck of the Retort is not immersed, the Joints must in this Case be closed with Lute: But if you imploy then too great a Fire, the Vessels burst violently asunder, with some Danger, because of the pernicious Fume. Besides, when your Fire is too strong, Part of the Silver easily gets into the Recipient together with the Mercury.

2. If, for Want of an *Apparatus* for Scorification and Coppelling, you have a Mind to indicate by this Method, the Quantity of Silver contained in the Body washed; in this Case, the whole Amalgama must be distilled through the Retort; because Part of the Silver and gold gets through the Leather: Nay, there remains nothing at all of the Silver or Gold within the Leather, if you use too great a Quantity of Mercury, to extract a small Quantity of these Metals: Unless the Mercury be saturated with them, by a like previous Process; and even then, you may be easily deceived as to the Quantity and Quality of the Metal.

P R O C E S S X I X .

To render Silver very pure, by Precipitation out of Aqua Fortis, with Spirit of Salt.

A P P A R A T U S .

1. **W**HEN Silver has been coppelled, dissolve it with *Aqua Fortis*, in a very clean Glass-Cucurbite: And if the Solution is the least in the World turbid, strain it through a double filtering Paper, into another clean Glass-Vessel. Pour into this Solution, by little and little, Spirit of Salt, or Solution of common Salt, or Salt Ammoniack, enough to produce a perfect *Aqua Regis* (*Part I. § 128. &c.*): The limpid Dissolution will immediately become milky: Let it rest for some Hours, that the Silver extracted in Form of a white Powder, may all sink to the Bottom: Which is sooner effected, by pouring a great Quantity of pure Water upon the Solution, if it be highly charged. This done, decant gently the Liquor at Top. But, you must pour upon the Calx adherent to the Bottom, fresh Water, or, what is still better, Phlegm of Spirit of Salt, or of *Aqua Fortis*; that all the Metal may be extracted out of it: For the Calx is no longer dissolved in *Aqua Fortis*, nor in Spirit of Salt. Finally, let it boil at several Times in fresh Water, till the Calx and Water are at last perfectly insipid. Shake them together, and pour them into a filtering Paper, that the Water may go through it; and then dry the Calx.

2. Put it into a Crucible, well rubbed on the Inside with Soap, and cover it with about one Half of any fixt alkaline Salt, very dry, and beaten to a very fine Dust: Squeeze the Whole well with your Finger: Cover the Crucible with a Tile, and put it in a Wind-Furnace, and make at first a middling Fire for a Quarter of an Hour, only to make the Vessels grow red-

red-hot; and then increase it as much as is required for a perfect Fusion of the Silver and Salt. The Fusion being obtained, take out the Crucible, that the whole may cool of itself; or pour it into an Ingot; the Silver shall be reduced perfectly pure out of this Calx.

3. If this Silver-Calx (No. 1.) is exposed alone to the Fire, it melts so soon as it grows red; and if you then increase the Fire a little more, it vanishes in Fume; when poured out quickly, it appears a Body of a light scarlet Colour, half-transparent, ponderous enough, and so tenacious, that it is difficult to reduce it to Powder, and if you break it, it seems to be of a fibrous Texture within: Whence it is called *Lunæ Cornua*, on account of its resembling the Horns of Animals on the Outside.

The Use and Reasons of the Process.

1. Silver is not to be dissolved the moist Way in *Aqua Regis* and Spirit of Salt; on the contrary, when it is already dissolved in *Aqua Fortis*, you precipitate it thence with Spirit of Salt: But so soon as this is done, a Solution of the Silver by the Acid of *Aqua Regis* happens in the dry Way: For a considerable Quantity of *Aqua Regis* is joined to the Calx of Silver precipitated to the Bottom; whence its Volatility depends. For this Reason likewise, if you mix a little of Spirit of Salt to Spirit of Nitre, you easily obtain the Separation of the former from the latter by Silver. See Part I. § 122. But the Copper whereof any small Quantity remains mixt with the Silver, in the Operation of coppelling, is not to be precipitated by Spirit of Salt: Therefore, when the other Metals are consumed in the Coppel, the metallick Part of this Calx is perfect and pure Silver. Gold itself is also perfectly separated in the same Manner, if the *Aqua Fortis* is not quite saturated by the Silver.

2. The Spirits must be pure, and the Calx perfectly well washed: Otherwise you will not always purify your Silver.

3. This *Luna Cornua*, must be reduced the dry Way, that is, by whatever absorbs *Aqua Regis* with great Force. Therefore you see this Property in some Metals, for Instance, in Lead, Tin, and all the alkaline fixt Salts. But the Silver is spoiled anew by the two former, and a great Quantity of it is destroyed at the same Time: Which may be guessed from the thick Smoak, which is produced in a violent Reduction made after this Manner. But all your Silver is preserved by a fixt Alkaly, provided you use a proper Course.

4. If you pour into the first Liquor remaining from the Precipitation, and decanted, a fixt alkaline Liquor, or a volatile urinous concentrated Spirit, in such Quantity as shall greatly exceed the exact Point of Saturation: The Colour of both, which was hardly sensible before, turns to a deep Azure, which must be owing to the Presence of Copper: For when this is in a small Quantity, it dissolves the moist Way in alkaline Salts, and then produces this Colour. The downy whitish Powder which is produced during this Mixture, and at first swims like Flocks of Wool, and then sinks to the Bottom, is not Copper, but proceeds from the Earth, which is produced in every Regeneration of neutral Salts, and to which the small Quantity of Gold, which possibly was in the Silver, is mixt.

P R O C E S S XX.

To extract Gold out of its Matrixs.

A P P A R A T U S.

ALL the Processes by which Silver is got out of the Ores in which it lies hidden, and is separated

rated from foreign Bodies, from *Proc. I. to XVIII.* belong to this Article. For Gold, as well as Silver, is free from the Action of Lead and Glass of Lead, and sustains the Coppel and the Test, in which all the other Bodies turn to Scoria's. Therefore, Gold mixt with Silver is collected in the very same Process by which the said Silver is separated from its Ores: as we have already mentioned several Times, in the foregoing Chapters. Amalgamation itself is more proper to Gold than to Silver; that is, as they are both separated from their Matrixs by this Operation: For there is no Metal, that is not more frequently met with in a State of Ore, than in its metallick State: But Gold is always found in a true metallick State; unless its Quantity is many Times inferior to that of the Silver adherent together with it in the same Matrix. But Gold, even in this Case, cannot always be said to be in a State of Ore (See *Part I. § 400*). Now, a true metallick State is required for an Amalgamation; because no Extraction can otherwise be made by Mercury.

There is indeed a great many Processes recommended by several Artificers, for the extracting of Gold out of its Matrix; and by which they say that you will obtain more than by the ordinary Method: But they, for the most Part, are so trifling and so tedious in the Work, that they hardly deserve to be described, so far they are from being worthy to be imitated. The most common of them are those, in which the Ore is prepared by roasting; which must not be always neglected; as it is sometimes altogether necessary. But to repeat it so many Times over, to extinguish the Ore after each roasting in Urine of Children, or in other Lies prepared in a particular Manner, then to scorify it first in a Crucible with Lead and other Ingredients, and afterwards to put it in a Test to scorify it a second Time, and so on, is a Method as silly as it is toilsome; by which Gold is rather dissipated than it is collected.

We have then nothing to do here concerning Gold, but to give the Methods by which Gold is separated from Silver, and those by which it is separated from the other Metals: as far as these Methods differ from those which we have already given, for the Separation of Silver from other Metals.

P R O C E S S XXI.

To render Gold perfectly pure from Silver, by Aqua Regis.

A P P A R A T U S.

1. **T**HE Mixture of Gold and Silver, must first be coppelled according to *Proc. II. or VIII.* with a sufficient Quantity of Lead, that the other Metals may be separated: In which a little more Lead is preferable to a lesser Quantity. Out of the remaining *Regulus* forge thin Plates; and whenever the Metal grows rigid under the Hammer, make it red-hot in a gentle pure Fire, whereby its Ductility will again be restored.

2. When the said Plates are sufficiently thin, make them red-hot for the last Time, and cut them into small Bits with a Pair of Sheers, and then keep them in a warm Place, in a Cucurbite made of transparent Glass, pouring upon them a sufficient Quantity of the purest *Aqua Regis*, which must be strong enough. In the mean Time, let the Orifice of the Cucurbite be shut close with a Cornet of Paper, to prevent any Dust from falling in.

3. The Dissolution being finished, pour out softly the supernatant Fluid into a wide open Glass-Vessel; taking Care that the least Part of the Silver, adherent to the Bottom in Form of a white Powder, does not go out along with it. Pour upon this remaining Calx some Phlegm of Spirit of Salt, and make it boil with it a while, that the residuous Dissolution of Gold may be washed off, and added to the first by decanting. This done,

done, inspissate the Liquors over a gentle Fire, till they are dry: Put what remains into a Crucible, and cover it with Powder of Borax, melted before-hand with a little Nitre: Cover the Crucible close with a Tile; and make the Melting first with a gentle, and a little after with a great Fire. Then pour it into a Mould to have an Ingot.

The remaining Calx of Silver being washed out of the Cucurbite, by pouring Water upon it, may in a wide Vessel be decanted, and being dried by Fire, may be melted in the same Manner.

The Use and Reasons of the Process.

1. All the Metals that are dissolved in *Aqua Regis*, must be consumed by Coppelling, before the Dissolution; lest, being dissolved together with the Gold; and inspissated, they be again confounded with it: But the small Quantity of Copper remaining after the Coppelling (*Proc. VIII. Us. N^o. 2*), being much divided by that Degree of Fire which puts Gold in Fusion, is destroyed partly by itself, partly by the Nitre, and turns to Glass, and is received by the Salts.

2. Gold may be precipitated quicker out of its Dissolution, by a fixt or volatile Alkali: But the Calx proceeding therefrom, which is of a dark yellow Colour, being dried on a gentle Fire, becomes that kind of Gold called *Aurum Fulminans*, because, when the Heat is not increased too suddenly, but only by Degrees, it decrepitates with great Violence, and with a thundering Noise, and scatters every Thing round it with such a Force as was hitherto never observed in any other Body. We shall soon teach, how this ought to be reduced, or rather separated from the Salts, which produce this thundering Noise together with it.

The ART of
PROCESS XXII.

To separate Gold from Silver with Aqua Fortis.

A P P A R A T U S.

1. **A**S *Aqua Fortis* cannot corrode Silver off from Gold, unless the former be three Times in greater Quantity than the latter (*Part I. § 472*); it is not every Mixture of Gold and Silver than can be separated by *Aqua Fortis*. Let therefore the Mixture of the white Allay be purified in a Coppel from the other Metals, if there is any in it; and be tried with the Needles (*Part I. § 295*). If the Allay of it is such, that it contains six Carats or less of Gold, and eighteen or more of Silver; you may reckon it fit to make a Separation with *Aqua Fortis*: If not, you must either add a sufficient Quantity of Silver by melting together in the Fire, or make the Separation with *Aqua Regis*, according to the foregoing Process.

2. Now, if the Mixture is so allayed, as to admit of the Action of *Aqua Fortis*; reduce it to small Plates; put it into a small Cucurbite, and pour upon it a double Quantity of *Aqua Fortis*, of a proper Strength, and tried, that the least Quantity of Silver may not be precipitated out of it (*Part. I. § 121, 122*); then put it in a warm Place, with a proper Cover. If the Bubbles and red Smoak, which are produced during the Dissolution, make you think that the Silver is corroded, decant the Solution, while it is yet warm, into another Glass-Vessel, and pour upon what remains fresh *Aqua Fortis*, but in Quantity twice as little as the first Time: Expose it again to the Fire, to make it boil; then decant it again warm, and repeat this once more; then wash the Residue with fresh Water; which will be your Gold, of a dark Colour, light, spongy, and brittle, out of which the Silver is corroded.

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3. You may pour it out, in the same Manner as you have done the remaining Calx of Silver, in the foregoing Process (N^o. 3). But the first Dissolution, being saturated, must either be drawn off (*Part I. § 125*) to separate from it the Silver, which will then be perfectly pure, or it must be diluted with Water: Put into it very clean thin Copper Plates, and immediately the Silver will first cover the Copper all over, under the Form of very thin and small Leaves, and then by Degrees be precipitated to the Bottom, and the Solution, which was before destitute of Colour, shall be tinged with a greenish azure Colour: Pour this together with the Calx into an edulcorating Vessel (*Part I. Plat. II. Fig. XIII*) and expose it a while to a Fire almost strong enough to make it boil: Thus all the Silver will at last be disengaged: Decant the Solution of Copper from the lighter Silver-Dust subsiding, and pour upon it at several times Water, which must boil till it becomes perfectly insipid. Finally, let the dulcified Calx of the Silver be melted together with Borax, first by a gentle Heat, and then by a strong Fire. But this Silver will not be perfectly free from Copper.

The Use and Reasons of the Process.

See on this Point (*Part I. § 472.* and the foregoing Process) and observe moreover, that, unless you pour out the Solution of Silver warm, some Crystals of Silver will be produced, very difficult to be dissolved, which surround the Remainder of the Gold in such Manner, that the Silver, remaining to be corroded off from the Gold with recent *Aqua Fortis*, is very difficult to be dissolved.

PROCESS XXIII.

The Silver remaining (Proc. XXI. N^o. 3.) retains something of Gold in it; and the Gold remaining (Proc. XXII. N^o. 2.) something of Silver.

A P P A R A T U S.

1. **I**F the Silver which (*Proc. XXI. N^o. 3.*) remains under the Form of a white Calx, is dissolved in the purest *Aqua Fortis*, there will remain at Bottom a small Quantity of a Powder not dissolved, and of a dark Colour; but the Part of it which melts into a *Regulus* and proves to be Gold is extremely small.

2. If the Gold out of which Silver has been corroded by *Aqua Fortis* (*Proc. XXII.*) is dissolved in *Aqua Regis* according to *Proc. XXI*, it leaves at the Bottom of the Vessel a small Quantity of white Silver Calx, which the *Aqua Fortis* had not corroded from the Gold.

The Use and Reasons of the Process.

1. Every Thing is plain in the two foregoing Processes: But, the *Aqua Fortis* or *Aqua Regis* are more or less pure, and of a proper Strength, according as they are more or less frequently poured recent upon the Mixture, and left to act a due Time upon the remaining Metal with a sufficient Heat. In short, the greater or lesser the Thickness of the small Plates of Silver and Gold is, and their Surface rendered more or less clean by the Fire; the more or less of the Metal, to be corroded by a proper corrosive Water, remains undissolved in the Residue of the Mixture.

2. If, therefore, you would have either of these Metals perfectly pure; this must be corroded off from the other by its *Menstruum*: Gold, for Instance, out of Silver by *Aqua Regis*, and Silver out of Gold by *Aqua Fortis*: But the Residue of the corroded
Body

Body remaining in the Mixture, commonly constitutes $\frac{1}{130}$ or $\frac{1}{200}$ of the Residue.

PROCESS XXIV.

To determine the Quantity of the remaining Silver which Aqua Fortis leaves in Gold.

THIS Process is not essentially different from *Proc.* XXII. and XXIII. N°. 2, except that many Cautions must be taken, and a perfect Knowledge of the Proportion of the Gold and Silver which constitute the Mixture, is required in the foregoing.

APPARATUS.

1. Take then of the purest Gold prepared according to the foregoing *Proc.* N°. 2. or to the XXIf, and altogether void of Silver, one docimaſtical Mark divided into Carats, and divide this into two Parts perfectly equal: Add to each of these Portions the Triple, that is one Mark and a half of the purest Silver (*Proc.* XXIII. N°. 2. or XXII. XIX). However, that the Mass may not be too great, you may take half a Mark instead of an whole one: Which must also be understood of the Parts of the Mark. Put every one separately into two Coppels well heated. Make a strong Fire, that they may be made red-hot: Then with a Ladle pour upon them one Centner of granulated tried Lead, not containing any ponderable Quantity of Gold in it. When the Lead has been consumed in a bright Fire, leave it still for one or two Minutes: Thus you will prevent the remaining of even the smallest Quantity of Lead (*Proc.* II. *Uf.* N°. 3). If both *Regulus's* are equiponderous in the docimaſtical Balance, the Operation hitherto has succeeded right, which otherwise must be repeated.

2. According to these Rules, make small thin Plates with an Anvil and Hammer, both perfectly smooth

smooth and polished; lest any Thing should be scraped off. Mean while, the Metal must be frequently made red-hot, under the Muffle, in a golden Dish put upon a Trivet (*Part I. Plat. II. Fig. XIV, XV*); lest any small Scales should go away from thence. Roll these Plates spirally, and after having made them red-hot again, put a small Plate of each Portion severally into two small separatory Cucurbites (*Part I. Plat. II. Fig. XI, XII*): Pour upon them some of the best tempered *Aqua Fortis*: Stop the Orifice of the Cucurbite with a Paper-Corner, or rather put upon it a Piece of flat smooth Glass: Because it is requisite that the elastick Spirits should have a Vent left them. If the Solution goes on then but slowly, you may put a small burning Coal under the Trivet. As for the rest, perform the Dissolution according to *Proc. XXII.*

However, take Care, mean while, lest the small Cucurbite be shaken, whereby the small brittle Plates of the remaining Gold, which had hitherto preserved their Figure perfect, might break asunder, or any Thing of this Substance be rubbed off. Having then decanted the Dissolution, invert the Cucurbites gently, that the small Plate rolled up may fall softly out of every one of them into the golden Dish put underneath.

3. Then set the Dish upon its Trivet, and put it under the docimastical Muffle, which must not be warmer yet than your Hand can bear, and out of which all the Ashes, which may have fallen into it, must have been blown first with a Pair of Hand-Bellows: Increase the Fire slowly, that the Dish may at last grow moderately red-hot within a Quarter of an Hour: This small Plate thus heated being grown cold, put it in a good Balance, to weigh it.

4. Then let the small Lamina of Gold, which is in the other small Cucurbite, be roasted in the same Manner, and put it in the other moveable Scale to compare it with the foregoing. They must be both perfectly equiponderous: if not, you have committed

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ted a Mistake, and the Process must be repeated. This done, put both Portions into one and the same Scale, and weigh them; you will find by the Difference of the Weight (N^o. 1.) that the Mark of Gold employed has been increased one or to Grains, which proceeds from the Residue of Silver which the *Aqua Fortis* could not extract. But if both Portions are less than the Mark employed, it is an infallible Sign of a Defect, to be understood from the three foregoing Processes. The Excess of Weight proceeding from the Residue of Silver, is called in German *Hinterhalt*, and must be noted exactly; that it may be subtracted from the Gold in the subsequent Quantation; that you may not believe that there was more Gold in the Mixture, than there is in reality.

The Use and Reasons of the Process.

1. By the foregoing Process (N^o. 1.) you cannot exactly determine, how much Silver remains in the Gold after the Separation by *Aqua Fortis*: For while the Gold is dissolved by *Aqua Regis*, it is a difficult Matter perfectly to collect the minute Dust of Silver, to free it from the Acid of the *Aqua Regis*, and to weigh it, without some Part of it being dissipated. But if Gold, dissolved by *Aqua Regis*, is again separated from it by Inspissation, Roasting, and Melting, it always suffers a Loss such as must be here considered over and above. For this Reason the Method already mentioned is chosen, to detect this Increase of Silver.

2. The melting of Gold with Silver, is made with greater Neatness and Perfection with a little Lead in a Coppel, than in a Crucible; nor is it then so easy to lose any Thing of the Gold. Of this you will be sure, if, after the Coppelling, you weigh again the *Regulus*, which must weigh four Marks: In this Case likewise you do not bestow afterwards your Labour
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in vain, when an Error has been committed in the Beginning. Nor do you lose your Labour or Time, if, after having made small Plates with the Mixture, you examine again the said Plates rolled up in a Pair of Scales: For then you not only are certain whether you have committed any Error; but you at the same Time detect the Cause of it.

3. Take Care that your *Aqua Fortis* be not too much concentrated, and that the Dissolution be not made more impetuous than is proper, by an excessive Heat, especially in the Beginning: For by so doing it happens, that the *Aqua Fortis*, which corrodes the Silver out of the Interstices of the small Plates, disjoins the Particles of the Gold by its elastick Effervescence, whence it is easy to lose Part of it. Likewise every moist Body, resolved into Fumes with great Hurry, may secretly carry away along with it Part of the inherent Body: Which is chiefly true with Regard to acid Spirits. Thence it is plain, that Silver mixt with Gold in much greater Quantity, may be corroded by *Aqua Fortis*, and at the same Time preserve the Figure which the Gold had before, if you know what proper Strength *Aqua Fortis* ought to have.

PROCESS XXV.

To investigate accurately the Allay of a Mixture of Gold and Silver.

APPARATUS.

I. **A** According to the Carat-Mark in little (*Proc. XXIV. N^o. 1.*) weigh of the Gold to be tried one half Mark; and after having found the Allay of it by proper Needles, put it into a Coppel with a sufficient Quantity (*Proc. VIII. N^o. 1.*) of Lead: That the Copper mixt with it may be consumed. If you have made the Coppelling in the End, with a Fire strong enough to dissipate all the Lead; you

you will be able to detect, by Needles of the white Allay, the Allay of the Residue of Silver and Gold, with still greater Accuracy, than at first by the Needles of the mixt Allay. If you then weigh the remaining *Regulus*, you know how much Copper there was in the Mixture. This Trial may be made previously, to know how much Silver must be added still, to prepare an Entrance for the *Aqua Fortis* into the Mixture.

2. Likewise, you must, for the Examination of your Gold, separate two Specimens, strictly observing the Cautions prescribed (*Proc.* XII. N^o. 1, 2), if the Circumstances require it. Let each of them weigh half a Mark: Put both severally into two Coppels well heated, and perform the Coppelling with a sufficient Quantity of Lead. When there is a Coruscation, add one Centner more of granulated Lead, and such a Quantity of the purest Silver, as that it may, together with the Silver already found in the Mixture (N^o. 1.) be threefold with regard to the Gold. We shall illustrate this Matter with an Example. Let us suppose, according to the Trial (N^o. 1.) that the half Mark has lost four Carats of its Weight in the Coppelling: Subtract them from the half Mark: There will remain eight Carats, which constitute the Gold and Silver alone: Let them be rubbed upon the Touch-stone, and agree with the Needle of the white Allay, which is marked with eighteen Carats of Gold, that is, in which one Part of Silver is mixt with three Parts of Gold: You thence know, that there are in the remaining *Regulus* of eight Carats, one quarter Part, that is, two Carats of Silver, and three Quarters, that is, six Carats of Gold. As then there must be three Times more Silver than Gold in the Mixture; add sixteen Carats of Silver, which, together with the two Carats already in the Mixture, make eighteen Carats.

3. Moreover, melt the Mixture in a Coppel, with the same Cautions as in *Proc.* XXIV. then reduce it to small Plates rolled up, and dissolve it in the same

same *Aqua Fortis* which you have used in the foregoing Process; then wash off the Salts with Water, roast, and, after having compared the two Residues in the Balance, weigh together the Gold remaining from the two half-Marks. Thus you will have found out with Certainty, and to the very least Weight, the Quantity of the Gold, which at first you could but have guessed with Uncertainty: Subtract from this Weight, as much as has been left of the Silver in the same Quantity, according to *Proc. XXIV.* Let us then suppose in the present Case, that the two small Plates of Gold remaining, weigh twelve Carats and six Grains, and that the Residue of the Silver, according to the foregoing Process, is two Grains in the whole Mark of Gold: Therefore, if there remains a little more than a half-Mark of Gold, you must subtract one single Grain; and there will remain twelve Carats and five Grains.

The Use and Reasons of the Process.

1. Observe besides what has been said in the foregoing Process, that you are not to employ any other *Aqua Fortis*, but that wherewith you have tried the remaining Silver: For, supposing the other Operations to be the same, the Difference of this *Aqua Fortis* makes the Difference of the Residue. Therefore, you must repeat the foregoing Process as many Times as you use other *Aqua Fortis*.

P R O C E S S XXVI.

The purifying of Gold by Cementation (Part I.
§ 459, 460.)

A P P A R A T U S.

1. CHUSE some Tiles, or Bricks, not vitrified by an excessive Fire, nor too much tempered with Sand: The oldest are the best. Clean them well from

from Lime and all other Filthiness, pound them in an Iron-Mortar, and then sift them through a coarse Sieve. Take four Parts of this Powder, and one Part of Colcothar not washed, and of common Salt, mix them together, the more the better, and grind them in the same Manner, as if you would make Spirit of Salt. Moisten these Powders with a little Water or Urine, so as that they may cohere when pressed between your Hands.

2. Take a clean earthen Vessel, quite sound, sufficiently thick, not glazed, and of the requisite Size (*Part I. § 218*), strew the Bottom of it with your moistened (*N^o. 1.*) Powder, or Cement, and distribute this every where with your Finger, pressing it down very gently, so that the Thickness of the Cement may be half an Inch all about. Put upon it Gold extended in thin Plates, not thicker nor larger than a Golden Duckat, and rendered perfectly clean by making them a little red-hot in the Fire, so that the Cement may be covered all over with them. Then put a second Layer of Cement after the foregoing Manner; and likewise the same Plates of Gold upon this as before, till the Pot is full to half an Inch Distance from the Brim of it. Let this remaining Space be filled up with Cement; then at last cover the Mouth of the Pot with a Tile, and stop the Joints close with Lute, lest the Spirits forced out by the Fire should have the Liberty to get out.

3. Put this cementatory Pot, thus filled, into a Furnace in which such a Fire may be kindled for several Hours, as that the Vessels put into it may be made red-hot in an equal Manner: Such is the *Atbanor* described (*Part I. Plat. IV. Fig. I*), in which the Vessels may be placed under or without a Muffle; in the Middle of the Coals, or in the first Chamber. At first, make a gentle Fire, and increase it successively, till the Pots grow middling red-hot, and not more: For if you should use too great a Fire, your Gold would melt, and again be in Part spoiled by the same Things corroded off by the Vapours of the Cement.

Cement. When the Vessels have been red-hot for sixteen or twenty Hours, take away the Fire, that the whole may cool of itself.

4. This done, open the Pots, take out the Cement, which must be softened by pouring Water upon it, in case it should have hardened too much. If there has been any Silver in the Mixture, you must preserve the Cement, as it contains in it the Metal which has been corroded from the Gold. After this, pour upon the Plates of Gold a little Water, to wash them clean, then make them boil in other Water, which you are to renew several Times, till it is perfectly insipid: For, there are saline Spirits, that lie hidden in the Plates of Gold, together with the Metal corroded by them. After that, try the Gold with the Touch-stone, or, more surely still, by Quar-tation, whether it has the Degree of Purity which you desire; unless you already know it, from a Series of repeated Experiments.

5. If your Gold is not yet sufficiently pure, cement it anew once or twice more. Workmen commonly add some Salt-ammoniac to the foregoing Cement, that the other Metals may be the easier corroded: But in this Case, there must be no Colcothar among the Ingredients, for it sometimes happens that Gold cannot be brought to a sufficient Degree of Purity, on account chiefly of the Copper which it is commonly mixt with.

The Use and Reasons of the Process.

1. This Process shews, that the Action of the Spirit of common Salt is different, according to its different Purity, and the different Degrees of the Fire. Likewise, if, instead of common Salt, you employ Nitre in the Cement, the Spirit of it being disengaged, consumes the Silver distributed in the greatest Part of the Gold: Which Effect it could not produce, even the moist Way, though it constituted two Thirds of the Mixture of Silver and Gold. For
the

the rest (See *Part I.* § 152, &c.) However, Fire cannot dissipate any Thing of Silver dissolved in this Manner; though it acquires such a Degree of Volatility, especially through the Spirit of Salt: This seems to proceed from the Action of the Air's being prevented.

2. Salt Ammoniac may also be employed in the second Cement; though the Spirit of Salt is more easily expelled out of it, even without any Addition: which is shewed by the Liquid that precedes its Sublimation. Besides, Salt Ammoniac itself has a very strong Power over the other Metals. But, as it is so very dear, and the whole Business may be performed at last with common Salt, Cements for this Reason may be done without it. The same Thing must be observed of all the other Ingredients, which enter into Cementations, besides those already mentioned. Observe moreover, that, by a Variety of Additions, you sometimes communicate to Cements a stony Consistence, which cannot be conquered, and lose pretty often Part of your Gold, or even change the acid Vapours to such a Degree, that they cannot exert their Action, or at least are of no Service at all; so that you increase your Charges much more than is necessary. Thus sometimes they prescribe several Proportions of Gem, Fountain, or Marine Salt, of which the different Effects are a perfect Secret to me. The same is true of the Bloodstone, the *Crocus Martis*, the white Vitriol, the costly Verdigrease, the blew-Vitriol, the plumose Allum, and the like; of which Kinds of odd Mixtures we have a Multitude prescribed by several Authors, who have written of metallick Matters.

3. If you have a Mind to purify brittle Gold by Cementation, it must be granulated, before you mix it with the Cement. But, as these Grains are not all made so fine, as that the Vapours may penetrate them thoroughly, the Granulation must be repeated as many Times, as they are to go through a new

T Cemen-

Cementation *. But the Grains, after each Cementation, must be separated from the Cement, by washing.

4. If a much greater Quantity of other Metals is mixt with the Gold, it is not proper to separate them by a Cementation; but in this Case, the Coppel and Precipitation by Fusion (*Part I.* § 466.) must be preferred.

5. As the Cement receives the Silver that was in the Gold, this may be reduced together with other the like Sweepings mixt with Gold and Silver. For this Purpose, those Things are melted at least with Lead-Ore or Litharge, and with the other Drosses of Lead, in the Manner described (*Part I.* § 240.) All the Silver and Gold is then received by the Lead, from which these precious Metals may afterwards be separated by the Coppel.

6. There are other Cements besides these, which are called *gradatory*; because they give Gold, though already perfectly pure, a much deeper yellow Colour than it naturally has. But Copper, or at least the Bodies proceeding from it, and not yet intirely destroyed, enter into all these Cements. For Instance, the Filings of Copper are calcined with Sulphur, and the *Crocus* proceeding therefrom, serves instead of Cement, either alone, or mixt with the common Ingredients of Cements; and the Gold cemented with it during twenty Hours is thereby rendered more yellow. The blue Vitriol has the same Virtue. But Verdigrease has it chiefly; and these Cements are commonly sprinkled with the Solution of Salt Ammoniac, and with Vinegar. But the Colour they give proceeds from the Copper which joins with the Gold; wherefore it is again dissipated by Lead, Antimony, and the ordinary Cements. Therefore, these Kinds of Cements, it seems, ought to be called *degradatory*, rather than *gradatory*, because they in Reality render Gold impure.

* Unless flattening them with an Hammer upon an Anvil may answer the same Purpose.

PROCESS XXVII.

The Precipitation and Purifying of Gold, by crude Antimony.

APPARATUS.

1. **B**EFORE you come to the Process itself, you must previously know the Allay of your Gold: which you may try either with the Touchstone, or with *Aqua Fortis* (Proc. XXII): For it is not necessary to try it by an exact Quantation. But the Diversity of the Allay of Gold demands a certain Variety in the Way of proceeding. If then the Quantity of the Gold in the Mixture is not less than three Quarters, that is, eighteen Carats, the Mass must be melted in a wind Furnace, and in the mean Time the Crucible be covered, to prevent Coals falling into it. This done, put into it at several Times the double Quantity of crude Antimony pulverized; in such Manner that so soon as one of the Portions put into it is melted, another be immediately supplied: Leave these Things melted in the Fire for some Minutes more; then pour them into the melting Cone (*Part I. Plat. II. Fig. XIX.*) which must be warm and rubbed with Tallow, and immediately strike with a Hammer the Floor on which the Cone stands; that the heavier Part freed from the Sulphur may the sooner sink to the Bottom: Invert the Cone when grown cold, and strike it. The Body that was poured into it will fall out, and have at Bottom a *Regulus* more or less yellow, according as there was more or less Gold in the Mixture. This *Regulus* may, with a gentle striking, be separated from the sulphureous Crust which is at Top.

2. Immediately after this, melt on a lesser Fire the said *Regulus* in the same Crucible, if it is intire: When in Fusion, add to it the double Quantity of crude Antimony, and pour it out a little after. Se-

parate the *Regulus* from the Antimony at Top, according to N^o. 1 : This you may repeat even a third Time.

3. Next, put this *Regulus* into a thick Test well conditioned : Place it before the Bellows, according to Process X, put Coals round it, and one or two Pieces of Wood upon them, and make a middling Fire, that is, such as is sufficient to melt the *Regulus*. The reguline Part of the Antimony will vanish in a thick Smoak : Towards the End increase the Fire more and more, and keep it so, till the Fumes are over, and the Surface of the Gold of a green and neat Colour. If the *Regulus* is but in small Quantity, this Operation may be performed with a Pair of hand-Bellows. Melt the remaining Gold with Borax and Nitre, according to Proc. XXI. N^o. 3 ; that, being freed of the small Quantity of *Regulus* of Antimony which may happen to remain, it may be rendered pliant : Which may be done still better by Cimentation, when there is Occasion.

4. But when the Gold is impure to an Allay of eight Carats ; it is not proper to perform the Precipitation by Antimony alone : But you must add to the Antimony as many Times two Carats of common Sulphur, as the Allay of the Gold is so many Carats less than eighteen. As for the Rest, let the Operation be made as N^o. 1. Likewise let the *Regulus* be melted twice or thrice more, with crude Antimony, and the reguline Part of this, which was joined to the Gold, be dissipated.

5. The sulphureous Mass swimming at Top of the *Regulus* (N^o. 1, 2, 4), and broken off from it, contains all the Metal separated from the Gold : Therefore it must be kept, that you may separate from it the Silver together with the small Quantity of Gold which has been carried away by it.

The Use and Reasons of the Process.

1. Crude Antimony, besides its reguline Substance, has in it about one Part of common Sulphur, wherewith the *Regulus* is joined. But this Sulphur dissolves with greater Efficacy the Silver and Copper wherewith the Gold is allayed; it abandons the *Regulus* (Part I. § 147. Coroll. 3) which sinks gradually to the Bottom, on account of its being heavier than those Metals which are dissolved by the Sulphur, and were mixt with the Gold before. But though the Gold itself does not admit this Action of the Sulphur; yet while the Silver and Copper are corroded by it, a considerable Part of it divided into minute Particles, is carried away at the same Time, and will not go again to the Bottom, unless the *Regulus* itself, joining with it, should constitute larger Particles, which are more quickly precipitated, because the Surface of Contact is diminished; and so melt into one *Regulus* together with the Gold remaining at the Bottom of the Vessel: Whence proceeds the pale yellow Colour of the Gold.

2. When the *Regulus* is separated, it must be melted again once or twice with fresh crude Antimony, that the remaining Silver and Copper may be separated from the Gold in the same Manner. Whence it is plain, that the more Gold is allayed with Silver and Copper, the greater Quantity of the *Regulus* of Antimony is precipitated, and joined with the Gold; and on the contrary. Thence again, the Reason is plain, why the Separation of Gold from Silver and Copper is not performed as well as could be wished with the Sulphur alone? Nor is it less evident thence, that the Separation of Gold from Silver and Copper must be attributed chiefly to the Sulphur of Antimony.

3. The *Regulus* of Antimony, which becomes volatile by a middling Fire, is easily dissipated from the most fixt Gold, by the Blast of the Bellows; but you lose something of your Gold, when you increase the Fire too soon, and too much. Nor is it yet easy, by this Means, to bring Gold to a perfect

Ductility, unless it is afterwards melted with Nitre and Borax (*Proc. XXI*), or intirely corroded by the Cement which remained from the Antimony.

4. As then the Sulphur of Antimony takes away the menstrual Force between the Gold, and Copper, and the Silver; and the reguline Part does but help the Precipitation; it is easy to find out, why it is not proper to precipitate Gold from the other Metals, with only Antimony, and that some more Sulphur must still be added. For unless this be done, a greater Quantity of crude Antimony is required, for the supplying of a sufficient Quantity of Sulphur: But then in this Case so much *Regulus* is precipitated out of it, and joined to the Gold, that you cannot dissipate it without Loss of your Time, Labour, and Gold: For this *Regulus* is very rapacious, nor does it altogether spare your Gold.

5. Such Gold, that is well purified by crude Antimony, is indeed so pure, that being compared with the purest Gold (*Proc. XXI.*) on the Touchstone, its pale Colour, proceeding from the Silver, is not easily perceived; but if the very same Gold is dissolved, according to *Proc. XXI*, by *Aqua Regis*, there appears nevertheless something of the Silver.

6. As the Sulphur of Antimony has in it the Silver separated from the Gold, this may again be precipitated out of it, according to *Proc. XVI*: But then at the same Time the remaining reguline Part of the Antimony sinks to the Bottom together with the Silver. Let then a Specimen be separated from this Mixture, and examined by Scorification (*Proc. I.*) and by Coppelling (*Proc. II*); this done, let the Residue of the Silver be put into *Aqua Fortis*, to know whether there remained any Gold joined with the Silver (*Proc. XXII*), and how much, if any: Which may afterwards be intirely precipitated, according to *Proc. XXVIII*, if it will pay the Charges. But the Antimony which is melted with the Gold already pure, as likewise that which is at three or four different

rent Times put upon any Gold of any Allay whatever, has a very small Quantity of Silver in it: Therefore, being hardly different from crude Antimony, if you mix it with fresh crude Antimony, it may again serve for the same Operations.

PROCESS XXVIII.

Precipitation of Gold by Fusion (Part I. § 466.) out of a Mixture eight Carats under Standard.

IF the Quantity of the Gold in a Mark of the Mixture, does not exceed three or four Carats, it is not convenient to make a Cementation, nor a Separation by *Aqua Fortis*, nor a Precipitation by crude Antimony: Which is self-evident, to any one who considers the Nature of these Operations, and the necessary Expences which attend them. Therefore, another Method must be used. Likewise, if you happen to have a Mixture of five, six, or seven Carats, fit to make a Separation by *Aqua Fortis*; you may perform the Separation the dry Way, when particular Circumstances will not admit of the foregoing Method.

A P P A R A T U S.

1. Find out by the Experiment of *Proc. XXII*, or by the Touch-stone, first, whether there is in the Mixture a Quantity of Gold sufficient to pay the Charges of the Separation, and whether it does not exceed three or four Carats. This being found out, granulate the whole Mixture which is to go through the Operation. Weigh half a Mark of the Grains dried, and then examine again the Proportion of the Gold and Silver, by an accurate Coppelling and Separation in *Aqua Fortis* (*Proc. XXV.*) This you do in order to know, whether all the Gold has been precipitated out of the Silver in the following Operation,

tion, or no. For if you take your Specimen out of the Granulation, you are perfectly sure of the Proportion of the Mixture.

2. Moisten slightly again with Water the granulated Gold, and put it into a hollow Vessel of a sufficient Capacity, and add common Sulphur pounded to a fine Powder one quarter Part with regard to the granulated Metal, and mix the whole well with your Hands, that a small thin Crust of the pounded Sulphur may adhere to each moistened Grain. Put this again into an earthen glazed Vessel, not much larger than is necessary to contain the *Granula* covered with Sulphur: Shut the Pot close with a Tile, and close the Interstices with thin Lute, and put it thus in the Middle of the Hearth of a Fire sufficiently large. Make a circular Forge round the Pot, distant from it about an Hand's Breadth all round; which must first be gentle, and afterwards increased gradually; that the Sulphur may be melted, and the *Granula* dissolved by it: It will be a Sign of this Dissolution, if Fumes and small sulphureous Flames begin to break forth here and there, through the Joints, or through Chinks that may happen to be made: Then remove your Fire, and when the Pot is grown cool of itself, break it: You will find a black Mass, which you must collect after having separated it from the Pieces of the Pot.

3. Make ready the wind-Furnace represented (*Part I. Plate III. Fig. VI, or Plate IV. Fig. I*), and in the Ash-Hole of it, make a Bed with Lute, to collect the Metal without any Loss, or any great Trouble, in case it should be spilt out of the Crucible that should happen to break. Put into this Furnace a Crucible full of the granulated Metal calcined in the foregoing Manner, putting under it a Piece of Tile well dried, for it to stand upon. Put upon this as many half Ounces of granulated Copper, as there are Marks in the Mixture in the Crucible; But if there is already Copper in the Mixture; do but compleat the Deficiency of every Ounce: But if there is but one half

Ounce of Copper in the Mixture, nothing must be added. Shut the Crucible close with a Tile, and fill the Furnace up to the very Brink of the Crucible, with pickt Coals of a middle Size, taking great Care not to leave any Vacuity: Kindle these Coals by throwing upon them burning Coals, that a Mass sufficiently fusible may be melted by a middling Fire: Try with an Iron-Hook pretty thick, whether the Fusion is perfect: Then stir the melted Mass with the same Hook not keeping it too long immersed, because it would soon be consumed. This done, have at Hand a precipitating Flux, composed of four Parts of granulated Lead, of Sandiver, of common Salt melted, and of Litharge one Part each, to which you may add one Part of Filings of Iron and of Copper. Weigh as many half-Ounces of this Flux, as there are Marks of the granulated Gold, and with an Iron-Spoon pour it thereupon at several Times, that it may be equally distributed all over the Surface of the melted *Granula*. After each Injection, stir the melted Mass with an Iron-Hook: that all the Things may be well mixt: Cover the Crucible with a Tile, and leave it thus for a few Minutes, before you throw in another Portion. Mean while, you must here and there supply with fresh Coals the Fuel that is consumed, taking great Care not to let it be wanting in any Place, lest you should thus render the Fire unequal; or lest, the Fuel being too much diminished, you should be obliged to add too much Coals at one Time: For, by that Means, the Vessels, especially the larger Ones, easily contract Chinks, and spill the melted Matter.

4. After the Quantity mentioned of the precipitating Flux has been put in, let the Matter remain in the Fire for about half a Quarter of an Hour more: Then pour it into a melting Cone, rubbed within with Tallow, or, if the Quantity is too great, pour it into a warm Iron-Mortar, covered over with a thin Lute, and made very hot: Immediately after this, put the Crucible again into the Furnace, and surround

round it with Coals: Mean while, invert the melting Cone or the Mortar, and throw out of it the Mass already grown solid. The inferior Part of it will be a *Regulus*, which consists of some Part of the Silver, and of the whole Quantity of the Gold that was in the Mixture. The upper-Part will be a Mixture of the Remainder of the Silver, and of Part of the precipitating Flux: Take off the *Regulus* and keep it: Put the sulphureous Mixture, broken and still warm, into the same Crucible; make it melt, and put upon it the same Quantity of the precipitating Flux, just as you did the first Time, that the *Regulus* may be again precipitated: Pour it anew into the Cone or Mortar; and, after having separated the upper Mixture from the *Regulus*, precipitate it a third Time, and by the same Quantity of Flux, in the same Crucible: Nay, if you find by the Experiment (N^o. 1.) that there is a great deal of Gold in the *Granula*; it will be proper to do the same for the fourth Time.

5. Finally, melt the precipitated *Regulus* in a new Crucible, and pour it into a Vessel full of Water stirred up with a birch-Broom, that it may be granulated: Then pour the second *Regulus* into the same Crucible, taking, mean while, the granulated Metal out of the Vessel: This done, granulate in the same Manner the second or third *Regulus*, and also at last the first; that you may have each *Regulus* granulated separately. Take of the dried Granulation of each *Regulus*, one docimaistical Mark of the smallest Weight, *Proc.* XXIV. N^o. 1, and try each of them separately in a small Coppel, to know whether any Part of the precipitating Metals has not perhaps been mixt with them, and how much. Then make the small Portions of Gold and Silver remaining in the Coppel go through a stricter Trial by *Aqua Fortis*.

You will find the Gold of the whole Mixture found out by Experiment, N^o. 1, either totally, or at least in the greatest Part, concentrated in the first *Regulus*:

But

But if any Part of the Gold is still deficient, it lies hidden in the *Granula* of the following *Regulus*. Besides, it is no Rarity, to find some small Part of the Gold in a *Regulus* that has been precipitated three and even four Times, in such Manner, however, that the first is always richer in Gold than the following. Now, this Granulation, which is not less than five Carats of Gold in one Mark, may afterwards be easily separated by *Aqua Fortis*, after having been previously purified in a Test (*Proc. XIV.*) But, if you have not yet such a Proportion, every Granulation that contains such a small Quantity of Gold as is worth the Charges of a Precipitation, must be cemented together with Sulphur, according to N^o. 2, and the Gold must be again fetched out of it with Part of the Silver, by a precipitating Flux, in the Manner just described (N^o. 3. & *fol.*) till the just Proportion is at last obtained.

6. The Silver, remaining in the sulphureous Mixture, is fetched out by Lead, or by Iron-Filings, in a large Test, or according to *Proc. XVI.*

If you have neither the Opportunity nor the Time, to separate from the Silver with *Aqua Fortis*, the Gold which is sufficiently concentrated in the *Regulus's*; the granulated *Regulus* may be cemented anew with Sulphur (N^o. 2.) to which you must add twice as much of crude Antimony, and the Gold may be fetched out by a precipitating Flux, in the Manner above described. Thus the Gold will sink to the Bottom, in the room of the Silver, together with the reguline Part of the Antimony. This done, you must melt again several Times the *Regulus* with fresh Antimony; that the Silver, which has at the same Time crept into the *Regulus* in a small Quantity, may be separated: Finally, blow away the reguline Part of the Antimony. See *Proc. XXVII.* Nevertheless, if you are not versed in these Operations, you can hardly perform this without some small Loss of your Silver and Gold.

The Use and Reasons of the Process.

1. This Method of Proceeding is used only in such a Case, when you have a great Quantity of Silver mixt with a small Quantity of Gold, nor can you determine the smallest Portion of Gold that will answer the Charges and Trouble of the Separation. Nevertheless, when Coals are cheap, and you have a good Quantity of Silver mixt with Gold, you may with some Profit separate one or two Grains (*Part I.* § 285.) or even one Penny-weight of Gold from it.

2. The Dissolution of Silver by Sulphur is performed in a close Vessel; otherwise, a vast Quantity of Sulphur would evaporate before the Dissolution should be made; unless you fix it by some other Body, for Instance by the reguline Substance of Antimony, as in *Proc. XXVII*, which Body, however, must not hinder the Action of the Sulphur upon the Silver.

Let the precipitating Flux be sprinkled as equally as possible upon the melted Mixture: For if this be neglected, and the Flux is gathered in a Heap in any particular Place of the Surface; the granulated Lead, which enters into the Flux, creeps out of it as soon as it melts, and coming down into the Mixture precipitates the Silver, which brings the Gold along with it from that Column only through which the Lead descends; and, falling further down, leaves the rest, which is adherent to the Sides, in the Mixture. For the same Reason, you must also stir up the Flux together with the Mixture, with an Iron-Hook. Likewise, Salts, Litharge, Iron, and Copper, perform a Precipitation, by absorbing the Sulphur, but they do it slower and more equally than Lead, and the two last still better, rendering at the same Time the Mixture specifically lighter, and more fusible, so that the Precipitation of the Particles of Gold and Silver is the better performed, and they hinder too great a Dissipation of the Sulphur. For this Reason, Gold mixt with a small Quantity of Silver

Silver is more exactly separated from the Mixture by this Flux well employed, than it can be without it, by means of Lead and Copper only. It is at the same Time evident, that one or the other Ingredient of the Flux may be spared, unless you have it at hand.

4. In this Manner, if any Part of the Gold has crept into the sulphureous Mixture (*Proc. XXVII.*) along with the Silver, it may be precipitated again out of it: Nor is there any other essential Difference between this and the foregoing Process, except that the Precipitation of the Gold is here helped on by Silver, whereas it is facilitated in the other Process by the *Regulus* of Antimony.

5. The rest of the Silver is precipitated out of the sulphureous Mixture according to *Proc. XVI.* This Precipitation is performed even to the smallest Quantity of Silver, when you do it first with Lead alone, and then with Iron: For then the Lead itself is again expelled out of the Mixture, and carries all the Silver along with it: Which can by no Means be done so exactly by Iron alone. The same may be performed with a little Lead in a larger Test; for this Mixture is nothing else than Silver dissolved with Sulphur: On which Account it may be compared with the richest and most fusible vitreous Silver-Ore (*Part I. § 385;*) as it has all the Properties of it, except that it contains a little Copper and Lead.

P R O C E S S XXIX.

The Separation of fulminating Gold from the Salts.

A P P A R A T U S.

TAKE Flowers of Brimstone two Parts, grind them in a Mortar, and, while you grind them, add to them at several Times one Part of fulminating Gold; that the whole may be equally mixt: Put this Powder into a Crucible, and put it upon a very gentle

gentle Fire, which is sufficient to melt the Sulphur, resolve the Sulphur partly into Fumes, and finally make it burn: When the Flame is vanished, increase the Fire, that the Vessel may grow red hot: When you see no longer any Smoak smelling of Sulphur, add a Quantity of Borax, which must be previously melted, and of Sandiver, and melt the whole in a great Fire: You shall have a Regulus of Gold at the Bottom.

The Use and Reasons of the Process.

1. Gold, *Aqua Regis*, and alkaline fixt Salt, when exposed to the Fire, do not fulminate; nor any two of these jointly; except that the fixt Alkali makes a small crackling Noise with the Acid of Sea-Salt, and Nitre accelerates with great Violence the consuming of inflammable Bodies in the Fire: But all the three, united together by Dissolution and Precipitation, produce this Phenomenon beyond all Expectation. No body has been able hitherto to give any Explication of this Event: For those, who attribute the Cause of it to the regenerated Nitre, do not consider that Nitre produces no Fulmination, unless you add a Phlogiston to it, and use a greater Fire than that required by fulminating Gold: Now, there is not in the purest alkaline fixt Salt a sufficient Phlogiston, nor do they detonate, when only joined to each other. But those who fancy that the Nitre has this Phlogiston from the Gold, are no less wrong: For in this Case, the Mixture of Gold would be dissolved: Whereas it happens on the contrary, that the Gold appears again perfect in the Form of a very fine Powder, when this Fulmination is performed with very small Portions, under a large Glass-Bell, and upon a very neat Surface. The crackling Noise of common Salt is no better an Explanation of the Case: For though it agrees in every Respect with the Fulmination of Gold, except the Violence; nevertheless, the Precipitation of fulminating Gold by a volatile Alkali,

by

by which common crackling Salt is not regenerated, is an Objection to this. The ammoniacal Substance which proceeds from the Acid of common Salt, &c. and from volatile Alkali, also detonates with Nitre: But if you take this for the Cause of the Detonation, the first Experiment is repugnant to it, by which fulminating Gold, having exactly the same Effect, has been produced by fixt Alkali: Nor does the Inclusion of decrepitating or detonating Salts, in the compact Body of the Gold, produce the Violence of the Fulmination: For if fulminating Gold is long boiled in Water, this its violent Strength perishes, and the major Part of the Salts may be washed off: Which could never be done, if they were inclosed in the Particles of the Gold, as in so many Vessels that should retain and imprison them. Therefore, the Explanation of this Point must still be fetched out of *Democritus's* Well.

OF LEAD.

PROCESS XXX.

To reduce and precipitate Lead out of a fusible Ore.
(Part I. § 456, 466.)

APPARATUS.

1. **B**EAT your Ore into a coarse Powder, just like the Grains of coarse Sand: Weigh of this Powder two docimastical Centners, and put them into a Test. Put upon this a Tile or another Test: But you must spread the comminuted Ore as wide as possible in the Test: Roast it next, first in a gentle Fire, which must be gradually increased, till the Vessel is almost red hot: Leave it thus for a few Minutes: then take off the Tile: and in a short Time the blackish Colour of the Ore will become of a yellowish ash-Colour: Which shews that the Sulphur is dissipated at least for the greatest Part.

2. Beat the roasted Ore into a subtil Powder, and add twice as much of the black Flux (*Part I. § 162*),
of

of Filings of Iron not rusty, and of Sandiver (*Part I. § 137.*) each half a Centner. Beat all these Things in a Mortar, that they may be well mixt together, and put them immediately into the Crucible, or into the Skillet (*Part I. Plat. II. Fig. V, VI, X.*) having twice or thrice as much Capacity; then cover them over, a Quarter of an Inch thick, with common Salt, and press them with your Finger. Shut the Crucible close with a Tile, or with some other smaller inverted Crucible, whose Brink may be received into the inferior one: Stop the Joint with such Lute as may bear Fire: and then dry the whole at a moderate Heat. But the Salts must be very dry, and not suffered to melt by too great a Slowness in the Operation.

3. Put the Crucible into the wind-Furnace (*Part I. § 240.*) and heap Coals upon it, so as that it may be covered over with them a few Inches high; govern the Fire in such Manner, that it may first grow slightly red hot. Soon after you will hear your common Salt crackle; and then there will be a gentle hissing Noise: So long as this lasts, keep the same Degree of Fire, till it is quite over. Then increase suddenly the Fire, till the whole Mass is melted: Which may be done in a Quarter of an Hour, in a moderate melting Fire. Take out the Crucible, and put it upon the Hearth of the Furnace, which must be very dry: Strike it a few Times with a Hammer, that the Lead, that may perhaps be dispersed in Grains at the Bottom of the Vessel, may run into a solid *Regulus*. When the Crucible is grown cold of itself, and broken, you will find the *Regulus*, which, being weighed, will shew how much Lead the Smelters may fetch out of the Ore. But the Silver, if there chances to be any, is by that Means precipitated along with the Lead, and must be detected at last by coppelling.

4. You will know that the Operation is happily performed, if the *Scoriae* subside in the Vessel, and if they do not foam over the Brink of the Vessel, and thus part of them make their Way through the
Lute:

Lute: Another Sign of Success is, when no Particles of Lead appear separate in the whole Vessel, but when they all gather into a solid, tenacious, ductil, bluish, not very bright *Regulus*; and when the Scoria's are hard, black and solid, except when there are a few small Cavities in the Middle, when they are contiguous with the common Salt: For the Salt does not mix with the Flux; but remains separate, and swims at Top, being however of a black Die. When the Scoria is soft, light, pulverulent, taking not much less room than the other Things put into the Crucible, this shews that, the Fire having been defective both in Strength and Duration, the Lead has not on this Account been sufficiently precipitated out of the Scoriæ; the same will be shewn by a rough *Regulus*, having high Protuberances, as also a blackish Brightness like that of the Lead-Ore, and finally by Grains of Lead inherent among the Scoria's especially towards the Bottom, in which Case the Operation must be repeated. The last Case sometimes happens, when a red hot Crucible is suddenly extinguished in Water, or put up in a moist Place. You know from the outward silvery Colour of the *Regulus*, that the Fire is too great or has lasted too long; you know it also, when the Scoria's and the Bottom of the Vessel appear covered with a Sort of white and neat Scale, while they are contiguous with the *Regulus*. The Operation has succeeded worse still, when the *Regulus* appears full of Cavities, when these Cavities seem to shine at the Inside, with an Intermixture of the Colours of the Rainbow, and when the Litharge has penetrated the Bottom of the Vessel.

The Use and Reasons of the Process.

I. To get Lead out of its Ore, you must first separate the heterogeneous Bodies, which make the Lead appear in the State of Ore: Such is the mineral Sulphur, which constitutes no inconsiderable Part of

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every

every common Lead-Ore. But this may be dissipated by roasting. (*See Part I. § 464.*) And as this Ore crackles, the Vessel must be covered in the Beginning of the Roasting. However let not the Vessel grow quite red hot, but only of a dark red Colour: For this Ore easily grows clammy, and the Vessel, by Corrosion, adheres so strongly to it, that it cannot be taken off without Loss. This Sulphur may also be separated without roasting, by Filings of Iron, when it melts on the Fire: but as some Lead Ores are charged with a semimetallick and chiefly antimonial Substance, which must likewise be separated from the Lead with Iron, it is better to let the Roasting precede: For Iron mixt with mineral Sulphur has no Action upon a Semimetal; but joints itself only to it; which we see from any Fusion of Iron made of crude Antimony, in which the Iron absorbs the Sulphur, and lets the reguline Substance sink to the Bottom. The Fear of those is altogether groundless, who imagine that Lead is spoiled by adding Iron to it; for, there is no Method known, whereby any Particle of Iron can be made to remain in Lead reduced into a metallick Form, as it is constantly and altogether rejected by it. (*See Part I. § 42.*)

Nor are you here to have any Regard to the refractory Quality of Iron; because, when it melts together with the Substances which it ought to absorb, it does it as soon as the Flux is added; and though it should not melt, the Lead may nevertheless be precipitated; because it does not in this Case adhere to the Interstices of the Iron.

2. But as the Phlogiston is dissipated out of the Ore during the Roasting, there remains a Matter that will turn into Glass with Fire alone: Therefore, something must be added that may supply the Place of the Phlogiston, such as the black Flux (*Part I. § 93. 162.*) To this you must add moreover Sandiver, that will bring to a quicker Fusion the black-Flux, which is refractory enough with regard to the Lead;

Lead; for Sandiver melts so soon as it begins to be slightly red. But the Vessel must be closely shut, lest the Phlogiston should be easily dissipated; for Experience has taught, that, in a Vessel well closed, a Piece of Charcoal, such as is the black Flux, can hardly be deprived of its oily Part, on Account of the Action of the Air's being hindered: The common Salt, that swims at Top, serves also for the same Purpose, as it stops every Way all immediate Communication with the external Air.

3. You are to observe as to the Regimen of the Fire, that in the Beginning it must be moderate for a while; because the Bodies reducible out of Lead, foam very much while they are reduced into a metallick Form by the Phlogiston, which you may perceive, if you pour a small Quantity of Charcoal-Dust, upon Litharge melting softly in a Test under the docimastical Muffle; and this happens by mixing a very small Quantity of Phlogiston; wherefore you seldom melt Litharge, but it foams and boils with a hissing Noise. For this Reason, if the Fire is encreased too much, the calcined Ore, exactly mixt with a Flux of Charcoal and Salt, rises into a Foam, makes its Way through the Lute, and the Lead is thus for the most Part dispersed in Grains. This is prevented, if you make the Fire not very great, till the Reduction is performed: Of this you have a Sign, when the noisy Ebullition, which happens during the Reduction, ceases; provided it is not occasioned by the Moistness of the Flux. But as this Reduction is performed in a Fire much greater than is necessary to melt the Flux itself, the boiling Matter is, mean while, retained by the Body still remaining solid, and hinder'd from dilating itself to such a Degree. Therefore, when the Reduction is at last made in a great Fire, you no sooner increase this, but the whole melts, so that the Lead adhering in Grains in the Flux may be precipitated. Nevertheless, a too violent Fire is more hurtful, than one continued a little longer than it ought to be. For

this Reason, a Fire that has a Draught of Air procured without Bellows, is preferable for the performing of this Process, to a Fire made with Bellows, because the Fire may be governed more accurately in the former than in the latter Case. It is better to leave the Vessels a little too long in the Fire, than to take them out too soon; for when the Fire is too slack, there is more of the Lead detained in the Scoria's than there can be consumed of it, by a proportionable Excess of the Fire; Therefore, unless you perceive Signs of a very great Excess, there is no need of repeating the Operation; whereas the repeating of it is unavoidable, if you find that the Fire has been wanting.

P R O C E S S XXXI.

To reduce and precipitate Lead from an Ore rendered refractory by Pyrites.

A P P A R A T U S.

R OAST two Centners of the Ore, (according to *Proc. XXX. No. 1.*) with only this Difference, that you must make a Fire a little stronger from the Beginning to the End. The Pyrites, especially that which is merely of Iron, hinders an Ore easily growing clammy, from turning into large Lumps, or intirely from melting. Beat the Ore roasted and grown cold to a subtile Powder, and repeat the Roasting a second, and even a third Time; till, growing at last a little red hot in the Fire, there does remain no Smell of Sulphur at all.

2. Mix the roasted Ore with six Centners of black Flux, and with two of Sandiver. Do the rest as in the foregoing Process; except that the Fire must be a little greater and longer continued in the End than if you had a fusible Ore to smelt.

The Use and Reasons of the Process.

1. If the Ores of Lead are charged with Pyrites, a greater Quantity of the saline Flux, which disposes these Earths to a Vitrification, is required, on Account of this refractory Quality, proceeding partly from the martial, and partly from the unmetallick Earth, and for the same Reason the Fire must be made a little stronger; that a sufficient Precipitation of the Lead out of them may be made.

As every Pyrites already contains a martial Earth in it, which is reduced to a metallick Form, when it is melted together with an oily reducing Flux, for this Reason, this Earth produces here the same Effect, that was produced by the Use of the Iron-filings in the foregoing Process; that is, it becomes capable of purifying Lead from the heterogeneous Bodies mentioned in the same Place. Nor does it hinder the Degree of the Fire which is used for melting the Lead-Ore, from being fit to precipitate Iron out of its Ore into a *Regulus*: For it is enough, provided it returns to its metallick State; which a middling Fire with some Phlogiston will effect; for then Iron is already fit for the above-mentioned Purpose. But you are to observe, that the martial Earth destitute of Phlogiston, and any Product of Iron whatever, deprived of Phlogiston, by the Violence of the Fire, is not fit to absorb Sulphur, Arsenick, Antimony, and the like; nevertheless, by joining the Phlogiston to it again, it recovers its former Virtue. You must likewise examine, whether the Pyrites is in a sufficient Quantity in the Lead-Ore; if not, its Defect must be supplied with a little Filings of Iron.

3. It is necessary to let a sufficient Roasting precede; for Iron, already saturated with Sulphur in a Pyrites, has not the same Effect as pure (*See Proc. XXX. Use N^o. 1.*) Iron. A strong Roasting is chiefly required, when the Pyrites are arsenical; for

Arsenick is much more fixt, and more strongly adherent to the Ores, than Sulphur; nay, when with a black Flux, it turns into a semimetallick *Regulus*, which being joined with Lead, a great Part of it most suddenly turns into (*Part I. § 73.*) Glass. And as there is but very little Iron in such a Pyrites; that Iron has not the Virtue of hindering this Effect of the Arsenick.

4. The Lead which is got out of such a pyritose Ore, is not commonly so pure as that which proceeds from a purer Ore; but it is found blackish and less ductile. The Cause of this Difference is Copper, which lies hidden in lesser or greater Quantity in every Pyrites, and which is reduced at the same Time, and melts with the Lead into one *Regulus*; wherefore it must be separated by a particular Eliquation,

P R O C E S S XXXII.

The washing of the Lead-Ore out of Earths and Stones.

A P P A R A T U S.

1. **T**HE washing of the Lead-Ore is performed in the same Manner, as that of the Silver-Ore. (*Proc. XIII.*) But take Care not to be deceived by the great Weight of the Ore; for when it is inclosed in a Matrix that is a little hard, the very brittle Lead-Ore, on Account of its foliaceous Texture, is, by the frequent Beating of the Pestle, broken into a very thin, scaly Powder, which swims in Water, in form of a blew Powder.

2. If the remaining Ore is rendered pure by the washing, let it be melted, as in *Proc. XXX.* If you find it pyritose and full of Iron, do what has been prescribed, *Proc. XXXI.*

P R O C E S S X X X I I I .

To precipitate Lead out of an Ore, rendered refractory by Earths and Stones, and not washable.

A P P A R A T U S .

TAKE of the roasted Ore two Centners beaten into a subtil Powder, mix them with an equal Quantity of Sandiver, the more exactly, the better; add also something of Filings of Iron, unless the Ore be of itself pyrituous; then mix the Whole with eight Centners of black Flux, and melt it as in *Proc. XXXI.*

The Use and Reasons of the Process.

Every thing is already clear from *Proc. XXXI.* There is need here of a very exact Commintion and Mixture, that the Scorification of the Stones mix'd with the Ore, and of the unmetallick Earth, may be performed with greater Ease, and that there may be no Necessity of promoting it with so strong and so long a Fire. On this Account also a great Addition of the Fluxes, especially of Sandiver, is required, to facilitate the Precipitation of the reduced Particles of Lead through the sufficiently attenuated Scoria.

P R O C E S S X X X I V .

To reduce and precipitate Lead out of any of its Ores, by Stratification with Charcoal.

A P P A R A T U S .

I. CHUSE for a docimaſtical Centner an hundred Half-ounces, or three common Pounds and four Half-ounces, that by this Means each Half-ounce
U 4 may

may stand in Lieu of one docimaistical Pound. Beat such a Centner of any Lead-Ore to a coarse Powder, the Particles of which must be about the Size of a Pea; put it into a large Earthen or Iron-Frying-pan, and heat it first by a gentle Fire, which must be increased gradually, that the greatest Part of the Sulphur may be dissipated.

2. Have at Hand a melting-Furnace, with a Bed made of Lute and Dust of Charcoal in its bottom-Part described (*Part I. § 239, 240.*); apply to this at the Outside, another Bed, (*ibid. Plate III. Fig. 13. lett. i.*) and join them with Lute, that the Matter running out of the inferior Hole when open, may be received into it; surround this outward Bed both with fresh and burning Coals, and fill the Furnace with the same Fewel that it may be dried; then with a Pair of Bellows excite the Fire for a Quarter of an Hour; and then put the Ore into it at several Times; nor will it be amiss to add to it some Scales* of Iron. But you must put the Ore in such a Manner, that it may be above the Coals, facing the Hole through which the blast of the Bellows is admitted into the Furnace: However let it not touch the Walls of the Furnace; for if it is cast upon the Side, where the Hole has been said to be, the melted Ore in its coming down is cooled by the blast of the Bellows, and the scorificated Part remains there more refractory than the Metal itself: it stops the Passage of the Wind, and hinders it from exciting the Fire freely and equally: If this happens to be the Case, you must remove the Scoria with a Poker, to be introduced through the oblong Aperture of the (*Plat. III. Fig. 10. lett. c.*) Bottom-part. In the mean Time, while the Ore is put into the Fire, the Furnace must be filled, two thirds at least, with Coals of a middling Bigness, and after each Portion of the Ore is put in, add a Layer of Coals above it.

* Such as flake off from Iron red hot, while under the Strokes of a Smith's Hammer.

3. When all the Ore is put into the Fire, continue to blow till the Fire is consumed in the Furnace. Pour Water upon the foremost-Bed, Drop by Drop, to cool the Lead gathered in it. Look also into the Scoria's, to see whether there are any Grains of Lead dispersed among them; if you find it to be so, beat the Scoria's, and wash the smallest Particles off with Water, that you may have the Lead separate. Finally, weigh this intirely: and the Weight will answer to that which the Smelter will at last have.

The Use and Reasons of the Process.

1. The Lead is reduced in this Process by its immediate Contact with the Coals; that is, the oily Part of the latter, being agitated by a great Fire, and intirely extorted, penetrates the small vitrescent metallick Particles, which being open by the Violence of the Fire run down through the Interstices of the burning Coals, which, in the foregoing Processes, was effected by the black Flux in close Vessels.

2. But this Method is preferable to the foregoing, except that the *Apparatus* is attended with greater Trouble. For when the Reduction is finished, the Lead, collected in the Bed of the bottom Part, runs thence into the outward or foremost Bed: there it is preserved by a much gentler Heat, under the burning Coals that supply it perpetually with a Phlogiston, and leaves its remaining Impurity. But take Care in this Operation, if you have a mind to make your Experiment with many common Pounds Weight, not to put too much at a Time to be reduced; for, if you do this, you will not make a sufficient Reduction, and the Fire is in some Measure suffocated. Nor must you put the roasted Ore into the Fire, before the Furnace and the Beds are well dried and made red hot on the Inside; for in this Case you will find Grains of Lead dispersed among the Scoria's. The same uses to happen, if the Ore is melted crude, or at least not sufficiently roasted: for, the Sulphur which adheres in great Quantity to the Lead-Ore, is hardly dissipated, and not separating quickly

quickly from the Scoria's, the Metal is rendered refractory and brittle. Besides let the Bellows not be loaded with too great a Weight; for this destructible Metal is partly consumed by the too great Violence of the Fire; especially when too impetuous an Action of the Air is joined to it. Let the Noſel of the Bellows not be too narrow; that a ſufficient Blaſt may be admitted: Nor is it always poſſible to compenſate this Narrowneſs by a greater Weight; for if you load the Bellows to an Exceſs, it has been found by Experience, that the Fire is thereby rendered equal, and even diminiſhed.

3. Gold and Silver may be reduced out of the Droſs, and united with Lead by this Method; if you add to them the vitreſcent Droſs of Lead, ſuch as is Litharge, and all the Calx of Lead, and the Things in which Bodies of this nature lie hid, or even the Lead-Ores themſelves. For all theſe Things, when they have recovered their Phlogiſton, are reduced into a metallick State, they abſorb the Gold and Silver out of their Droſs, and render the refractory Scorixæ fuſible and ſoft. But the Lead thus got may be again ſeparated in a large Teſt, or even be uſed to purify ſome other Gold or Silver, ſo that the Metal which is already in the Lead, may be added to them. See *Proc.* X, XI.

PROCESS XXXV.

The Separation of Lead from Copper, by Eliquation
(Part I. § 468.)

WHEN Lead has ſomething of Copper in it, it is thereby rendered leſs ductile, and when broken, the Surface of it appears as it were granulated, if the Quantity of the Copper is but very little increaſed; on the other Hand, when its Toughneſs makes it cohere, if you break it, it looks like a Heap of acute priſmatical Particles. Finally, if there is a great Quantity of pure Copper in it, it looks
reddiſh;

reddish; but if it is mixt with Sulphur, it looks blackish, and is very brittle: But the same Effect is produced by the Semi-Metals, as by Sulphur and Arsenick. Nevertheless, the Separation of the two latter has already been made in the foregoing Process; but the Copper must be separated by a peculiar *Apparatus*:

A P P A R A T U S.

1. Make with Lute and Charcoal-Dust a Bed, the Capacity of which must be proportioned to the Quantity of the Mixture of Lead and Copper to be separated. But let this Bed be very low, and declining forward towards the lower Part. Let there be a small narrow Channel running from the Bottom of the Bed, to the other Bed which is contiguous to the fore-Part of the former, and placed a little lower. In the Place where this Channel leads out of the End of the upper Bed; put a small Iron-Plate, and press it across the Channel still moist; in such Manner, that there remains only a small Passage at the Bottom of it, through which the melted Lead may run slowly. Dry the whole well, by putting red burning Coals thereon.

2. Put the Mixture of Copper and Lead into the upper-Bed: Make in both Beds, with Wood or Charcoal, a Fire gentle enough that it may only bring the Lead to a Fusion: This being melted by Degrees and slowly, will run through the narrow Passage left between the small Iron-Plate and the Bottom of the small Channel, and will be collected into a *Regulus*, in the lower Part of the foremost Bed. If nothing more runs with this Fire, make it a little stronger, till the Bed grows dark red-hot: Continue the Fire thus for some Minutes; and then put it out.

3. You will find the Lead collected in the inferior Bed; but the Copper that was in the Mixture, will remain in the upper-Bed, with a little Lead adhering to the Outside of it; whence it has the Colour of it,
and

and is full of Pores; and if the Copper is not a quarter or a fifth Part less than the Portion of Lead, and the Fire has been made gentle and slow, you will find that it has intirely preserved the same Figure, which the Mixture had before the Eliquation.

4. Find the Weight of the Copper with a Balance, and put the whole, or the melted Part of it, into a Test, or, if you are only willing to try it, put it into a small Coppel well heated, and sufficiently hot, till the Lead is intirely consumed, and the Copper remains motionless: Then take it out immediately, and extinguish it in Water. You will find the former Weight of the tried Specimen diminished: But the Part of it which is deficient, will be the Lead destroyed: And as Lead, mixt in small Quantity with Copper, consumes about the fifteenth Part of the Copper, with regard to itself; for this Reason, you must add the fifteenth Part of the deficient Weight to the remaining Copper, that you may have the Portion of Copper, which has been left by the Lead in the upper (N^o. 2.) Bed. Thence you may easily calculate, how much Copper may be separated from Lead. If you put the melted Lead into a Coppel, you will find not only the Portion of Gold and Silver which was in the Mixture, and which the Lead has carried away with it; but you will know also, from the pure sulphureous yellow Colour of the Coppel, or from its greater or less Blackishness, whether nothing, or a little, or a great Quantity of the Copper has vanished with the Lead; though you cannot however, from this, precisely determine the exact Quantity of it.

The Use and Reasons of the Process.

1. Lead, when it is not more hot than only enough to be in Fusion, does not dissolve Copper: Whence Lead may be melted in a Copper-Vessel, when you do not exceed this Degree of Fire: But,
so

so soon as the Lead begins to grow white, to smok and boil, it soon dissolves Copper: Therefore, you are to take Care, that the Fire be not too violent, especially in the Beginning. But the most simple Operation of the Eliquation, is that which is performed without any Addition.

2. The small Iron-Plate is applied, to the End that, in case a few small Particles of Copper should go off, these swimming at Top may be stopt there, and the Lead run as it were through the narrow low Passage left, as through a Sieve, while these Particles of Copper remain.

PROCESS XXXVI.

To reduce and precipitate Copper out of a pure and fusible Ore, in a close Vessel.

APPARATUS.

1. **M**IX one, or, if you have small Weights, two docimaistical Centners of Ore beaten extremely fine, with six Centners of the black Flux, and having put them into a Crucible or a Pot, cover them one half-Inch high with common Salt, and press them down with your Finger: But let the Capacity of the Vessel be such, that it may be only half-full; shut the Vessel close; put it into the Furnace, and make the Fire as in *Proc. XXX.*

2. Increase the Fire slowly, till you hear the common Salt put upon the Ore crackle: Then increase the Fire immediately, either, with the Funnel and Cover put upon the Furnace, or with a Pair of Bellows applied to the Hole of the bottom-Part, that the Vessel may grow very red hot. Thus you will precipitate and reduce your Copper in about a Quarter of an Hour: Then take out the Vessel, and strike with a few Blows the Pavement upon which you put it, that all the small Grains of Copper may be collected in one Mass.

3. Break

3. Break the Vessel, when grown cold, in two, from Top to Bottom, as neatly as you can: If the whole Process has been well performed, you will find a solid, perfectly yellow, and malleable *Regulus*, adhering to the Bottom of the Vessel, with Scoria's, remaining at Top of a brown Colour, solid, hard, and shining, from which the *Regulus* must be separated with several gentle Blows of a Hammer; this done, weigh it, after having wiped off all Filthiness.

4. A soft, dusty, and very black Scoria, is a Sign of a Fire not sufficiently strong. Small neat Grains of Copper reduced, but not precipitated, and adhering still to Scoria's, especially not very far from the Bottom; and an unequal and ramificated *Regulus*, are Signs of the same Thing. A solid, hard, shining, red-coloured Scoria, especially about the *Regulus*, or even the *Regulus* itself when covered with a like small Crust, are Signs of an Excess in the Degree and Duration of the Fire.

The Use and Reasons of the Process.

1. You may consult what has been said in *Proc. XXX. Uf. N^o. 1, 2.* But all the Ores which are easily melted in the Fire, are not the Objects of this Process; for they must also be very pure. Such are the vitreous Copper-Ores, but especially the green and azure coloured-ones, and the *cæruleum & viride Montanum* (Part I. § 363—366.) which is not very different from them. But if there is a great Quantity of Sulphur, Arsenick, or of the Ore of another Metal or Semi-Metal joined to the Ore of Copper, then you will never obtain a malleable *Regulus* of pure Copper; though Ores are not always rendered refractory by the Presence of these.

PROCESS XXXVII.

To reduce and precipitate Copper out of Ores (Proc. XXXVI.) rendered refractory by Earth and Stones that cannot be washed off.

APPARATUS.

1. **B**EAT your Ore into a most subtil Powder, of which weigh one or two Centners, and mix as much Sandiver to them: This done, add likewise four Times as much of the black Flux, with respect to the Ore: For, by this Means the steril terrestrial Parts are better disposed to a Scorification, and the reducing and precipitating Flux may act more freely upon the metallick Particles freed of all their Incumbrances.

2. As for the rest, make the *Apparatus* according to *Proc. XXXVI*; but you must make the Fire a little stronger for about half an Hour together. When the Vessel is grown cold, and broken, examine the Scoria's, whether they are as they ought to be: The *Regulus* will be as ductil and fine as the foregoing.

The Use and Reasons of the Process.

1. Every Thing has been already explained in *Proc. XXXIII*: But as such Copper-Ores hardly conceal any Sulphur and Arsenick in them, the Roasting would be of no Effect, and a great deal of Copper would be lost: For no metallick Calx, except those of Gold and Silver, improperly so called, can be roasted, without you find a Part of the Metal lost after the Reduction: But the Stones, which here are supposed not to be elutriable, cannot be separated by Fire alone: See *Part I. § 338*.

P R O C E S S X X X V I I I .

*To precipitate Copper out of an Ore (Proc. XXXVII.)
that contains Iron.*

A P P A R A T U S .

1. **D**O all according to *Proc. XXXVII.* But you will find, after the Vessel is broken, a *Regulus* upon no Account so fine, but less ductile, wherein the genuine Colour of the Copper does not perfectly appear, and which must be further purified.

The Use and Reasons of the Process.

The Fire used in this Operation, is not quite so strong, as that the Iron may turn to a *Regulus*: But as Copper is the *Menstruum* of Iron, which is of itself very refractory in the Fire; for this Reason, while the Ore and the Flux are most intimately mixt and confounded by Trituration, the greatest Part of the Iron, being dissolved by the Copper, turns into a *Regulus* along with it.

P R O C E S S X X X I X .

The roasting of a pyritose, sulphureous, arsenical, semi-metallick, Copper-Ore.

A P P A R A T U S .

1. **B**REAK two docimaistical Centners of the Ore to a coarse Powder, put them into a Test covered with a Tile, and place them under the Muffle of the docimaistical Furnace: But the Fire must be so gentle, as that the Muffle may be but very faintly red hot. When the Ore has decrepitated, open the Test, and continue the Fire for a few

few Minutes; then increase it by Degrees, that you may see the Ore perpetually smoaking a little: In the mean Time it is also proper, now and then to stir it up with an Iron-hook: The shining Particles will assume a dark red or blackish Colour: This done, take out the Test, that it may grow cold; if the small Grains are not melted, nor strongly adherent to each other, hitherto all is well; but if they run into one single Cake, the Process must be made again with another Portion of the Ore, in a more gentle Fire.

2. When the Ore is grown cold, beat it to a Powder somewhat finer, and roast it by the same Method as before; then take it out, and if the Powder is not melted yet, beat it again to a most subtil Powder; in this, you are to take care that nothing be lost.

3. Roast the Powder a second Time in a Fire somewhat stronger, but for a few Minutes only: If you do not then find the Ore any Way inclined to melt, add a little Tallow, and make it burn away under the Muffle, and do the same another Time again, till, the Fire being very bright, you no longer perceive any sulphureous, arsenical, unpleasant Smell, or any Smoak; and there remains nothing but a thin, soft Powder, of a dark red, or blackish Colour.

The Use and Reasons of the Process.

1. Every Pyrites contains Iron, with an unmetallick Earth: To which Sulphur or Arsenick, and most commonly both, (*Part I.* § 316, 323, 347, 369, 371.) always join. Besides, there is Copper in many Pyrites, but, sometimes more, sometimes less: Some of them (*ibid.*) are altogether destitute of Copper. Therefore, so much as Pyrites differ with Regard to the Proportion of their constituent Particles, so much do they differ as to their Disposition in the Fire. For instance, the more Copper there is in a Pyrites, the more it inclines to Colliquation. The more Sulphur and Arsenick it has in it, the more quickly the melting of it is procured, and the Reverse: The

more

more Iron and unmetallick Earth it contains, the more it proves refractory in the Fire. Now, if such Pyrites melt in the Roasting, as happens to some of them, if they grow but a little red-hot; the Sulphur and Arsenick that lyes hidden therein, are so strictly united with the fixt Part, that you would in vain attempt to dissipate them: Nay, in this Case, when it is reduced again into a Powder, it requires a much greater Time, and Accuracy in the Regimen of the Fire, to perform the Operation. For this Reason it is much better to repeat it with new Pyrites. But you can roast no more than the double Quantity at once of the Ore you have a Mind to employ in the foregoing Experiment: to the End that the Precipitation by Fusion not succeeding, there may remain still another Portion intire; lest you should be obliged to repeat a tedious Roasting: If you see the Signs of a ferreous refractory Pyrites, the Operation must be performed with a greater Fire, and much more quickly. However, take Care not to do it with too violent a Fire: For a great deal of Copper, is consumed not only by the Arsenick, but also by the Sulphur, and this happens even in Vessels shut very close; when the Sulphur is expelled by a Fire not quite so strong: Which a reiterated and milder Sublimation of the Sulphur, in a Vessel both very clean and well closed, will clearly shew.

2. When the greatest Part of the Sulphur and the Arsenick is dissipated, by such Causes as promote Colliquation, you may make a stronger Fire: But then it is proper to add a little of some fat Body; for this dissolves mineral Sulphur, it changes the Mixture of it in some Part, which for Instance consists in a certain Proportion of Acid and Phlogiston, and at the same Time hinders the Metallick Earth from being reduced into Copper, by being burnt to an Excess. From these Effects the Reason is plain, why Assayers produce less Metals in the trying of Veins of Copper, Lead and Tin, than skilful Smelters do in large Operations. For, the former perform the

Roasting

Roasting under the Muffle, with a clear Fire, and without an oily reducing Menstruum; whereas the latter perform it in the Middle of Charcoal or of Wood, which perpetually emit a reductive Phlogiston.

3. The darker and blacker the Powder of the roasted Ore appears, the more Copper you may expect from it: But the redder it looks, the less Copper and the more Iron it affords: for roasted Copper dissolved by Sulphur or the Acid of it, is very black; and Iron, on the contrary, very red.

4. If a pure Copper-Ore lyes hidden, together with Ores of other Metals or Semi-Metals, full of Sulphur and Arsenick, in one and the same Glebe, that cannot be separated with the Hand, it must be roasted: For, while the Copper is reduced and precipitated together with these other Metals, it participates of their Sulphur and Arsenick; wherefore, it is the same as if the Ore of the Copper itself had been defiled by them.

PROCESS XL.

The Precipitation of Copper, out of roasted (Proc. XXXIX.) Ore.

APPARATUS.

DIvide the roasted Ore into two Parts: Each of them shall go for a Centner: add to it the same Weight of Sandiver, and four Times as much of the black Flux, and mix them well together: As for the rest, do all according to *Proc. XXXVIII*: The precipitated *Regulus* will be half-malleable, sometimes quite brittle, now and then pretty much like pure Copper in its Colour, but sometimes whitish, and even blackish: Whence it is most commonly called black Copper (in German *Schwartz Kupfer*); though it is not always of so dark a Dye.

The Use and Reasons of the Process.

1. It is easy to conceive, that there is as great a Difference between the several Kinds of this Metal called black Copper, as there is between the pyritose and other Copper-Ores, accidentally mixt with other metallick and Semi-metallick Bodies. For, all the Metals, the Ores of which are intermixed with the Copper-Ore, being reduced are precipitated together with the Copper; which is brought about by Means of the black Flux. Wherefore, Iron, Tin, Lead, the reguline Part of Antimony, and Bismuth, most commonly are mixt with black Copper, in a Multitude of different Proportions. Nay, it is self-evident that Gold and Silver, which are dissolvable by all these Matters, are collected in such a *Regulus*, when they have been first hidden in the Ore. Besides, Sulphur and Arsenick are not always altogether absent. For they can hardly be expelled so perfectly by the many preceding Roastings, but there remain some Vestiges of them, which are not dissipated by a sudden Melting, especially in a close Vessel, wherein the Flux swimming at Top hinders the Action of the Air. Nay, Arsenick is rather fixt by the black Flux, and assumes a reguline Semi-metallick Form, while it is at the same Time preserved from dissipating, by the Copper. But, the Variety of the Colours, of the Consistence, and even of the Goodness of black Copper depends on this.

PROCESS XLI.

The running down of Pyritose, crude, Copper-Ore, into a rough, brittle Regulus, by a Stratification with Charcoal.

APPARATUS.

CHUSE a Weight of as many common half-Ounces for a docimaetical Centner, as there are Pounds in a large Centner, that each half-Ounce may represent a common pound Weight; weigh in a large Balance one or many Centners of crude Ore not roasted, and broken in small Pieces of about the Bigness of a Pea. Let the melting Furnace have a fresh Bed, and be altogether disposed as in *Proc. XXXIV. N^o. 1. and Part I. § 239, 240.* Stop with the same Lute which the Bed is made of, the Hole of the Bottom-part, through which the Body melted may run from the inward into the outward and foremost Bed. When the Furnace and both Beds are well dried and made white hot within, put the Ore into them at several Times; mean while let the Furnace be constantly kept full of Coals, and the Bellows blow very strongly at the same Time; let the Nose of these be directed obliquely downwards, that it may determine the Flame towards the Surface of the inward Bed, and of the Matter which is melted in it, to make it keep in a State of Fusion: All which Particulars must be observed more exactly than in *Proc. XXXIV. N^o. 2.* because of the refractory Scoria. But if you know from the outward Appearance of the Ore, or from the Experiment already made before, that this Ore, or the Scoria which will be produced out of it, is of a refractory Kind; it is proper that you should add a fusible Scoria, that has already born the Fire several Times, and is well tried that nothing of any Metal can be reduced out of it, of which you cannot de-

termine the Proportion with Regard to the Ore, otherwise than by Trial.

2. When you have put one Centner of the Ore into the Fire, continue the Fire, till you can judge that all the Ore is collected into the Bed: Try with an Iron-poker, which you are to introduce into the Bed through the oblong Hole of the Bottom-part, whether all the Ingredients are melted; especially if the Scoria's are melted thin enough, or have a pitchy Consistence; for, such must be fetched out of the said Hole with the Poker, lest the Inferior Aperture, through which the melted Matter is conveyed into the outward Bed, should be obstructed. Then, with an Iron Rod cutting at one of its Ends, open the Hole that is stop't with Lute; that the melted Matter may run out into the hot foremost Bed. Now, if you have a Mind to melt many Centners of your Ore; remove from the Hole the small Coals, or the tenacious Remains of the Scoria's; and stop it with fresh Lute: This done, take the hardened Mass out of the fore-most Bed, with a Pair of Tongs: Then you may, in the same Manner, put into the Fire, melt, and convey into the foremost Bed, another Centner of your Ore.

3. When all the Ore you intended, has past through the Furnace, and the Fire is consumed, and the Furnace grown cold, break the Beds; that you may collect what has been insinuated into the Chinks, which they possibly have contracted during the Operation. Likewise, examine closely the broken Scoria's, that you may see whether any Thing of the reguline Part has been detained therein: This must be separated either with the Hand, or by washing; and examined in the Balance together with the *Regulus* collected in the outward Bed, which is purged of all Scoria's. But, the *Regulus* in which the Metal lyes still hidden in its State of Ore, will be very brittle.

The Use and Reasons of the Process.

1. In this Fusion, the Ore melts on Account of too sudden an Application of the Fire; for this Reason it loses its Sulphur and Arsenick only in a small Quantity (*Proc. XXXIX. us. N° 1.*) the rest joins more strictly with the fixt Substance of the Ore. Therefore, as Iron, which abounds in every Pyrites, separates the Sulphur and Arsenick from all the other Metals and Semi-Metals, and unites them to itself (*Part I. § 147. coroll. 1.*); on this Account these heavy Bodies sink to the Bottom, and the Iron, freed of Sulphur and Arsenick, swims at Top, together with the unmetallick Earth. But this Separation does not succeed so perfectly, but there remains something of the Iron and of the unmetallick Earth in the *Regulus*, and some Copper in the Scoria's: The Reason of this is, that the Iron which is in the pyritose Ore is not sufficient to absorb all the Sulphur and Arsenick, and that by Means chiefly of the Arsenick, which, together with the Metals, turns to a reguline Semi-metallick Substance, Part of this subtil Earth remains joined to the *Regulus*. This *Regulus* is called *Lapis Cupri*, in German *Rohstein, Kupferstein, &c.* because it has hitherto preserved the Nature of the crude Pyrites.

2. But every pyritose Copper-Ore must not be made to go through this rough Melting; but only that which has a great Deal of Iron and a little Copper in it. For, the Reason why the melting is done here without a previous Roasting, is, (1.) that the Iron may be separated from the Copper; which is performed like a Precipitation by Fusion, through the Action of the Sulphur upon the Iron (*N° 1.*): Nor could the Separation of so much Iron from the Copper be made with any Benefit by another Method. (2.) That the melting may be performed conveniently: For if an Iron-pyrites is deprived of its Sulphur by roasting, it is hardly tractable by Fire alone, on Account of the refractory Nature of the martial Earth: This may

be observed in any Iron-Ore, though it be ever so fusible in its kind; because it wants a far more violent Fire to be melted, than any other Ore whatever. Nay, it is proper also here to use an unmetallick Earth, altogether unfusible by itself, which enters in greater Quantity into the Composition of the Pyrites, as it contains a lesser Quantity of Copper. But both these are freed, by a violent Fire suddenly applied to them, from the Sulphur which is in some Measure fixed in the Pyrites, and cannot evaporate very quickly; and the Iron is at the same Time separated from the Copper, and thus the Copper is freed from Sulphur, by Means of Iron, and reciprocally from Iron, by Means of Sulphur.

3. By the same Method, you will obtain Silver, Gold, and Copper, if the Ores in which they lie hidden, are dispersed among a great Quantity of Stones and Pyrites, which admit of no Washing; nor can the Metal be separated therefrom with Benefit, by any other Method hitherto known: for Instance, after such an Ore has been beaten to a coarse Powder, if there is not already a sufficient Quantity of yellow sulphureous Pyrites in it; you must chuse sulphureous Iron-pyrites, and even among those you have at hand, those that contain the greatest Quantity of Silver, Gold, and Copper; for by this Means you obtain in one single Operation, and at the same Expence, the abovesaid Metals, which sometimes cannot be fetched with Benefit out of the Pyrites, by a particular Process. You must add fusible Scoria's to these Ores and Pyrites, especially those that remain of the Melting of Lead-Ore, and those chiefly out of which a little Lead may still be fetched; or even the very Ore of Lead itself: Nay, some other additional Ingredients too, that are easy to be melted either of their own Nature, or at least by the Methods here prescribed, and the Quantity and Choice of which can hardly be determined with Certainty, otherwise than from a long Experience in these Matters, by Experiments, and a great Attention to every Circumstance

Circumstance. All these Things pass through the Furnace, whence proceeds a *Regulus*, in which Gold, Silver, Copper, and Lead are concentrated, but in a rough Manner (N^o 1.): However, the Lead which chiefly receives the Gold and Silver, is sometimes collected into a *Regulus* by itself, and gets to the lower Part of the Bed, with an Abundance of Scoria's.

4. The Precipitation of the Ore out of the scorificated Stones, must be chiefly attributed to the Pyrites in the Process. For the Martial Earth which is in the Pyrites, leaves its Sulphur in the very Beginning, when the Fire begins to act; and this Sulphur being agitated by so great a Fire, carries away a great many metallick Particles, especially of Iron (*Proc. XXXIX. us. N^o 1.*): Therefore, both these, which are found every where, the Stones, that conceal Ores and are intermixt with them, being broken small, dissolve and penetrate them, and dispose them to a Scorification; which happens the more constantly, because Sulphur is so strongly fixed by Iron Particles adherent to it, that it cannot evaporate very quickly, though it is exposed to ever so violent a Fire. The other Part of the Martial Earth turns to a Scoria, which, by adding Scoria's that contain Lead, and other fusible Matters, dissolves the Stones intirely, and bring them to a Fusion. Then the Ores get free therefrom, and are precipitated; and their remaining Part of martial Earth being reduced to a metallick State, absorbs a little of the Sulphur and Arsenick: On this Account the Metals are concentrated into a solid weighty *Regulus*, with which a great Quantity of the reduced Iron mixes. Therefore you are to make the following Observations concerning this Process. (1.) That Sulphur is necessarily required, and that the above-mentioned Operations are performed by the Concurrence of it, is very plain, because the Pyrites destitute of Sulphur is not capable of assisting the Scorification, but is rather an Obstacle to it, by its refractory Quality. (2.) That Iron is not only of a scorifying

scorifying, but also of a precipitating Nature, since it absorbs Sulphur and Arsenick : For a Scorification may be performed by the Lead-Ore, or its Scoria, and by adding other Fluxes : But the greatest Part of the Lead is retained in the Scoria's, together with the metallick Part inherent in the Ores, when a Pyrites containing Iron is wanting: Nay, Lead itself, cannot be sufficiently, and sometimes not at all precipitated out of its Ore, and rendered pure, without the Assistance of Iron. (3.) A too great Quantity of Arsenick is hurtful here, and for the most Part hardly reducible into Glass, on Account of its Rapaciousness, and of the Destruction of the Lead (*Part I. § 73.*) But a great Deal of the Arsenick is also fixt with metallick and unmetallick Earths, and is mixt with both of them: Whence very coarse *Regulus's* are produced; the Scoria's, on the contrary, retain a great Deal of the Metal: Thence are also produced Semi-arsenical Substances, that are distinct from the Scoria's and the *Regulus*, containing chiefly Copper and Iron; which are called by the German Metallurgists *Kupfer-leg*, when they contain a great Quantity of Copper with Iron; but are called *Speise* by the same, when they consist only of Iron and Arsenick: These have much of the unmetallick Earth in them.

PROCESS XLII.

The melting of Pyritose crude Copper-Ore, in a close Vessel, to make a Regulus like that of Proc. XLI.

APPARATUS.

- I. **T**AKE two Centners of the small docimaistical Weight of that Ore not roasted; beat them to a fine Powder, mix them with twice or thrice as much of pulverised common Glass, which you are to have at Hand, and which must be very fusible: Or, instead of this use Scoria's altogether destitute of a metallick reducible Earth, and easily melting in the

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Fire.

Fire. Put them into a Crucible or Pot; and cover them over with common Salt, shutting the Vessel Close with a Tile, and stopping the Joints with Lute.

2. If these Things melt in the Wind-furnace, by Means of a violent Fire, you will find at the Bottom of the Vessel a *Regulus* like that of *Proc. XLI*.

The Use and Reasons of the Process.

1. No sulphureous Ore that has not been roasted, ought to be melted by adding to it an alkaline Flux: For, fixt Alkali together with mineral Sulphur, turns to a Body, called *Hepar Sulphuris*, which retains in it dissolved metallick Bodies (*Part I. § 149.*): For this Reason, if you melt in the Fire an Ore containing a great Deal of Sulphur, or of the Acid of it, with a black or a white Flux of an alkaline oily Nature; you either have no *Regulus* at all, or at least the greatest Part of it is detained in the Scoria's, that is, according as there is in the Ore a greater or a less Quantity of the Metal to be precipitated. If the Ore is mixt with Sandiver, and exposed to a melting Fire, the *Regulus* is easily precipitated out of this most fusible Salt: But this *Regulus* most commonly retains the Colour of the Pyrites itself, and when exposed to the Air in a short Time turns to a brown and very salt Powder; which shews, that a great Quantity of Salt has mixt with it: Nor is the Scoria that swims at Top destitute of Metal, which renders both the Weight and Quality of the *Regulus* uncertain.

2. This Mixture of Sulphur with oily alkaline Matters, most commonly must be acknowledged to be an accessory Reason, why the Ore melted in close Vessels, or the Metal itself, when mixt with Sulphur, afford a lesser Quantity of pure Metal, than when the melting is performed in an open Fire; unless some precipitating Metal is added: As, for Instance, Iron in the melting of Lead: But this does
not

not succeed in the present Case: for Iron, that may be mixt with Copper while it precipitates it, mixes in great Part with the precipitated Copper. For, according to the most accurate Experience, the precipitated participates of the precipitating Body, if not in all, at least in a great many Precipitations; and this happens in the moist as well as in the dry ones; Nevertheless, this happens sometimes more, sometimes less.

P R O C E S S X L I I I.

The further Purification of the Regulus's of Proc. XLI. and XLII, to make Black Copper.

A P P A R A T U S.

LET the *Regulus* be beaten to a coarse Powder, and be roasted and comminuted several Times over, that the Sulphur and Arsenick may be dissipated (*Proc. XXXIX.*): Then, let it be reduced with the black Flux (*Proc. XL.*) or by Stratification with Coals. The *Regulus* thereby produced will be like that of *Proc. XL.*

The Use and Reasons of the Process.

1. As the *Regulus's* of the foregoing Processes, are made of the Particles of the Pyrites melted together, with this only Alteration in the Proportion of the Ingredients, that there is less Sulphur and Arsenick, and less also of the subtil unmetallick Earth in the *Regulus's* than there was in the Pyrites out of which they have been produced (*Proc. XLI. N^o. 3.*): It is necessary to make previous Roastings by the same Methods that were prescribed *Proc. XXXIX*, to make the black Copper so called *Proc. XL.* Nay, one or two Fusions must sometimes precede the Roastings, when the *Regulus's* are very coarse, and tainted with a great Quantity of Iron; that the Iron may, by a repeated Precipi-

Precipitation, and by the Sulphur and Arsenick still remaining, be separated from the Copper; whereas, both Metals would otherwise be confounded together by a subsequent Fusion, the Sulphur and Arsenick being intirely dissipated, and could hardly be separated (*Proc. XLI. Uf. N^o. 2.*)

P R O C E S S XLIV.

To find out how much pure Copper may be produced by Scorification, out of black Copper.

W Hsoever attempts to find this out with the Touch-stone, must be acquainted with the Use of the Proof-needles (*Part I. § 289.*); one of which must be made of the purest Copper, the others of black Copper more or less pure; the Nature and Goodness of which may be ascertained by the foregoing Experiments. Then the Copper to be examined, must be rubbed upon the Touch-stone, and compared with the Needles rubbed upon it in the same Manner. If the black Copper is of the best Kind, after having compared the Colour and Ductility of it with the Needles, you may in some Measure judge of the Goodness of it. But, if it is less pure, you can conclude nothing that is certain by this Method; because the Colour and Consistence of Copper may be changed by many Causes, sometimes by one, sometimes by several at once, there being a Multitude of Proportions that concur to vary it a thousand different Ways. For, Copper, for instance, is rendered white equally by a great Deal of Tin, by a little of Bismuth, and by a very little Arsenick. What will then be your Uncertainty, if many other Causes concur with those just mentioned, to increase it! You must then examine your Metal by another Method.

A P P A R A T U S.

1. Separate a Specimen of your black Copper of the Weight of two small docimaſtical Centners at leaſt; and do it in the ſame Manner, and with the ſame Precautions, as if you would detect a Quantity of Silver in black Copper (*Proc. XII. No. 1, 2.*)

2. Then with Lute and Coal-duſt make a Bed in the Cavity of a Teſt moiſtened: When this Bed is dry put it under the Muffle of the docimaſtical Furnace, in the open Orifice of which there muſt be bright burning Coals, wherewith the Teſt muſt likewiſe be ſurrounded on all Parts: When the Whole is perfectly red-hot, put your Copper into the Fire, alone, if it contains Lead; but if it is altogether deſtitute of it, add a ſmall Quantity of Glaſs of Lead, and with a Pair of Hand-bellows, increaſe the Fire, that the Whole may melt with all Speed: This done, let the Fire be made a little leſs violent, and ſuch as will ſuffice to keep the metallick Maſs well melted, and not much Greater. The melted Maſs will boil, and Scoria's will be produced that will gather at the Circumference. All the heterogeneous Matters being at laſt partly diſſipated, and partly turned to Scoria's, the Surface of the pure melted Copper will appear: So ſoon as you ſee it, take the Pot out of the Fire, and extinguiſh it in Water: Then examine it in a Balance, and if Lead has been at firſt mixt with your black Copper, add to the *Regulus* remaining of the pure Copper, one fifteenth Part of its Weight, which the Copper has loſt by Means of the Lead: Then break it with a Vice, and thus you will be able to judge by its Colour and Malleability, and by the Surface of it after it is broken, whether the purifying of it has been well performed, or no. But, whatever Caution you may uſe in the performing of this Proceſs, the Product will, nevertheless, be always leſs in Proportion than what

what you get by a greater Operation; provided the Copper be well purified in the small Trial.

Another Method.

1. Take black Copper, chosen in the same Manner as before (N^o. 1.) and break into small Pieces a Quantity of it a little more than two docimastical Centners: This may be done very well with a Hammer and a Chizzle; that the small Bits may be made of the Size of large Pieces of granulated Metal: Then reduce it to the exact Weight of two Centners: Weigh also two Centners of pure comminuted Copper: Add to each, being granulated, an equal Weight of pure granulated Lead, not having the least Appearance of a Mixture of Copper, which may be distinguished from a dark Colour remaining in it, when you vitrify it alone in a Coppel: Wrap up both these granulated Metals separately in small Bits of Paper.

2. Put two Coppels under the Muffle, and heat them for a While with a strong Fire: This done, put your granulated Metals into them; and bestow all your Care here to hinder the Action of the Fire from being greater upon one Coppel than upon the other. However, let the Process be performed with a pretty strong Fire: When all the Lead is consumed, and the Smoak ceased, take both Coppels out of the Fire, as nearly at the same Time as possibly you can, and extinguish in Water the remaining Beads of Copper: Then weigh them, and as much as there is wanting of the two Centners of pure granulated Copper, so much are you to add to the *Regulus* remaining of the two Centners of black Copper; because a like Quantity of it has been consumed by the Lead: But if the black Copper contained Lead of itself, observe, besides, the Difference of the Weights of both *Regulus's*, and add furthermore the fifteenth Part of it. You will have gathered by this Means the Weight of pure Copper that may be fetched out of the black one. Let, for Instance, the *Regulus* remaining of the

two

two Centners of pure granulated Copper weigh 186 *lb.* This has lost 14 *lb.* by the Coppelling. If the *Regulus* remaining of the black Copper weighs 154 *lb.* you must of Course add 14 *lb.* to the 154 *lb.* thereby to restore as much Copper, as has been consumed of your Copper by the same Lead, and in the same Degree of Fire: The Sum 168 will indicate how many Pounds Weight of pure Copper may be fetched out of the black one. But if the black Copper had already some Lead in it; this being consumed, carries away with it about the fifteenth or sixteenth Part of the pure Copper, which must of Course be added over and above. But you may take for the Quantity of the Lead, the Difference of the *Regulus's* remaining after the coppelling; Therefore in the Example just proposed, the Difference between 186 and 154 will be 32: For which Reason you must add two Pounds; and the whole Weight will be 170 *lb.* This Method proves more exact than the foregoing.

The Use and Reasons of the Process.

1. This is the last purifying of Copper, whereby the Separation of the heterogeneous Bodies begun in the foregoing Processes, is completed as perfectly as it possibly can be. - For, except Gold and Silver, all the other Metals and Semi-metals are partly dissipated and partly burnt together with the Sulphur and Arsenick: But, in the Fusion, they either turn of themselves to Scoria or Fumes; or this is performed by Means of Iron, which chiefly absorbes Semi-metals, Sulphur, and Arsenick, and the Destruction of it is at the same Time accelerated by them. Thus the Copper is precipitated out of them pure: For it is self-evident, that the unmetallick Earth is expelled, the Copper being reduced from a vitrescent terrestrial to a metallick State, and the Arsenick being dissipated, by Means of which the said Earth has been chiefly joined to the coarser *Regulus's* of the first Fusion. But there is at the same Time a good Quantity of the Copper that gets into the

the Scoria's; however a great Part of it may be reduced out of them by repeating the Fusion.

2. However, though Iron, when melted alone, or even with Copper, is most easily burnt, and scorified; nevertheless, when it is once melted, and confounded with Copper, it can never be entirely separated by Fire alone, without the greatest Part of the Copper be destroyed along with it. Therefore, according to the Diversity of the Ores, and of the Skill they are managed with, there is a vast Difference in Coppers produced by divers Processes, not only from many different Ores, but even from Ores of the same Kind: which Difference almost always depends upon the Iron mixt with them: But, this is easily separated by a little Lead: For the latter that can upon no Account be mixt with Iron in a metallick State, dissolves the Copper, and rejects the Iron; but the Lead itself not being able to sustain so strong a Fire, resolves partly into Fumes, and partly into Scoria. This is also the Reason, why a better Kind of Copper is got from Copper-Ores that contain Lead, and from black Copper from which Silver has been separated by an Eliquation made with Lead, than would have been got, had Lead been altogether wanting. Therefore, when black Copper containing Lead is to be purified, it is not without Reason, that you add to the remaining melted Copper, the fifteenth Part of the Portion, which has been lost in the Operation, that the Quantity of pure Copper that lies hidden in the black Copper, may be more exactly determined: On the other Hand, Iron has been so much rejected in the foregoing Processes, that it hardly deserves any Consideration: Which is likewise true of many other Bodies that are joined with Copper. However, you must examine whether the other Circumstances will permit it: Because black Copper is yet sometimes full of a great Quantity of Sulphur: But if the latter abounds, it is proper to separate it before the Excoction, by roasting, and by a reducing Fusion, with an Addition of something

thing that absorbs Sulphur; for Instance, of Scoria of Iron.

3. Observe, as to the Application of the Fire in this Process, that it must be applied to Copper with all imaginable Speed, to make it soon run: For, if you neglect this, a great Deal of your Copper is burnt: Because Copper that is only red hot, cleaves much sooner and in much greater Quantity into half scorified Scales, than it is diminished in the same Time, when melted. However, too impetuous a Fire, and one much greater than is necessary for the Fusion of it, destroys a much greater Quantity of it, than a Fire sufficient only to put it in Fusion, would do. For this Reason, when the purifying is finished, the Body melted must be extinguished in Water, together with the Vessel; lest being already grown hard, it should still remain hot for a While.

4. As there is more or less Copper destroyed by the same Quantity of Lead, on Account of a different Regimen of the Fire, the surest Way is to make two Operations at once, when Lead is superadded to the black Copper, or when the Operation is made together with Lead in a Coppel. For, by this Means, you may conclude from the Portion of pure Copper destroyed, the Quantity of which is exactly known, how much of the pure Copper the same Weight of Lead has carried away with it from the black Copper; as likewise, how much of it was burnt by itself. But, though you should use ever so many Cautions, you will never have in a small Process a Product proportionable to that of a large one: For, imperfect Metals are sooner or later destroyed, according as they are exposed to a greater or less Surface of Air: Now, a smaller Mass, *ceteris paribus*, is respectively exposed to a larger Surface of Air, than a larger Mass: Wherefore, more is lost of a smaller than of a greater Quantity. To remedy this in some Measure, several Centners are employed for the Experiment: But the Nature of the Operation is such, that you

you can neither intirely correct, nor altogether exclude the Action of the Air.

5. It is proper here to mention the Danger occasioned by a fortuitous or imprudent Application of Water, or of a moist, nay, of a merely cold Body, to melted Copper *. For, of all Metals there is none that scatters with so great a Violence all the Things round it, as melted Copper, especially boiling purified Copper, called in German *Gahr-Kupfer*; infomuch, that the Fall of a Coal, or of a small moist or cold Stone, has often broken asunder whole Furnaces, and burned whole Laboratories: And this happens especially, if but a small Quantity of Water extended wide, touches a large Surface of Copper. Likewise, Copper that begins to grow solid, being thrown on a moist, cold, but especially wide Surface, flies about with great Danger to those that stand by, and of setting the Building on Fire. Wherefore, if you have not a Mind to be exposed to the same Danger, you must take Care in the Granulation of Copper by Water, that it may fall from a sloaping Surface, or through a bored Vessel, and with a small Stream, into Water that is stirred about with great Force.

* *N. B.* There is the same Danger in melted Brass or Bell-Metal, or any other Mixture, whereof Copper makes a Part; so that Founders of all Sorts should be equally cautious in this Respect: A melancholy Accident of this Kind happened at the Brass Foundry at *Windmill-hill* near *Moorfields*, *London*, about twenty Years ago, when several People of Quality were invited to see the Casting of two large Brass-Cannon at a Time; the Heat of the Metal of the first Gun drove so much Damp into the Mould of the second, which was near it, that as soon as the Metal was let into it, it blew up with the greatest Violence, tearing up the Ground some Feet deep, breaking down the Furnace, untiling the House, killing many of the Spectators on the Spot with the Streams of melted Metal, and scalding many others in a most miserable Manner.

P R O C E S S X L V.

Examination of the Scoria's of the foregoing Processes concerning Copper.

A P P A R A T U S.

IF the Scoria is much charged with Sulphur, beat two or three docimaistical Centners of it to a subtile Powder, and mix it, either alone, or, if its refractory Nature requires it, with some very fusible, common, pounded Glass, without a reducing saline Flux, and melt it in a close Vessel, and in a Fire having a Draught of Air, as in *Proc. XLII*: You will have a *Regulus* like that *Proc. XLII*.

But when the Scoria has little or no Sulphur at all in it, take one Centner of it, and with the black Flux manage it as you do the fusible Copper-Ore (*Proc. XXXVI*): You will have a pure *Regulus*.

But, if you have a Mind to try a greater Quantity of Scoria, perform the Operation according to (*Proc. XLI*.)

The Use and Reasons of the Process.

1. While Metals are precipitated by Scorification, and with a melting Fire, out of the solid Bodies in which they are inclosed, the Scoria's, on account of their Clamminess, most commonly retain something of the Metal (*Part I. § 98. Schol.*): Besides, when the just Quantity of Phlogiston is wanting, and the Fire is either too strong or of too long Duration, a great Deal of the already precipitated *Regulus's* of the Metals of an imperfect Mixture, being half-vitrified, turns to Scoria's again: Likewise, the Excess of Sulphur and Arsenick is oftentimes an Obstacle to a sufficient Precipitation, especially when precipitating Matters are wanting, or misapplied: Finally, the Destructibility of the Metal itself, hinders one from attempt-

attempting a complete Precipitation at once : It is better to separate only the Part which is first expelled out of the Scoria's ; and these afterwards are exposed to a reducing reiterated Fusion : Which Method is the more beneficial ; because these Scoria's serve sometimes instead of a *Menstruum* to melt other Ores, and thus leave at the same Time the Metal remaining in them.

2. From these Things, might perhaps be explained the pretended Observations, how a new Generation of Metals has been operated, by the Influence of the Stars and of the Atmosphere, in Scoria's rejected a great while ago.

3. The perfect Scoria coming out of pure Copper, out of Stones, and other vitrified Bodies is of a blue Colour. But, if there is in it more Copper not quite vitrified, it looks reddish ; and the more still, as it contains more Copper : Wherefore, a great Quantity of Copper may also be reduced out of such a Scoria. But this Colour may be intirely obscured, by the Addition of many other Bodies, especially of metallick ones : Which is chiefly effected by Iron ; because a small Quantity of it gives the Scoria's a very black Colour. For this Reason, you must never neglect a docimastical Examination of the Scoria's. But the metallick *Regulus's* which are precipitated out of them, are as various as those produced by the Ores themselves. For, the *Regulus's* which is precipitated out of the Scoria's of (*Proc XLIII.*) the pyritose-Ore, is much coarser than the first *Regulus* proceeding from it : For a precipitating Iron lies hidden in the Scoria's united with Sulphur, when the greatest Part of the finer Metal is expelled : Therefore, the *Regulus* which is especially called by the Germans *Schlack-Stein*, is more full of Iron and Sulphur. Thus, all the *Regulus's* produced from the Scoria's are commonly less good than those obtained by the foregoing Processes : Because there is a greater Number of heterogeneous, and chiefly of fixt Bodies, in the Scoria's, which, on this Account,

must be compared with an Ore much impurer; than that from which the Scoria's are produced.

P R O C E S S X L V I.

The Elutriation or Washing of Copper-Ore.

A P P A R A T U S.

1. **H**ERE every Thing must be done as in the Washing of the Ores of the foregoing Metals: But you are to observe in a special Manner, that the green and blue Okers of Copper (*Part I. § 366.*) admit of no washing; although they lie hidden in a soft and not very ponderous Earth: For, they are very light, and are carried to very great Distances, by Waters not very rapidly moved.

2. The green Copper-Ores, and the blue azure ones (*Part I. § 364, 365.*) can never go through any Roasting, without cleaving into a light blackish Powder: And as Copper, next to Iron, is of all other Metals the most easily burnt away, if the roasting is continued a little longer, or even repeated, Part of the best Copper is lost, that can by no Means be recovered. For this Reason, as the abovesaid Ores are at once light and easy to be reduced to a subtile Powder, they will not bear washing, unless they are adherent to Earths, or at least intermixt between very soft and light Stones, very easy to be comminuted by a previous Roasting: And even in this Case some Loss or other is hardly to be avoided. However, beware not to take for such Ores those, to the Surface of which a small insignificant Crust of the blue or the green Oker has applied itself.

3. The other pyritose, sulphureous, Copper-Ores, inclosed in hard ponderous Stones, on Account of the Sulphur they contain, suffer, and even require a Roasting; not only to the End, that the Stones may be disposed to a more convenient Comminution, but also that the Ore itself may be rendered more weighty and

and solid: For these Kinds of Ores are very brittle and light, and are comminuted more easily and finely by pounding, than the crude Stone itself: Whence they afterwards are, for the greatest Part, carried away by Water.

4. Therefore, when you meet with Ores that are difficult to melt, on Account of Stones intermixt with them, and either not separable at all, or at least so with great Difficulty, and never without some Loss of the Ore itself, it is better to manage them according to *Proc. XLI. Us. N^o. 3.*

PROCESS XLVII.

To find out Copper in a pyritose Ore, by Solution, and a liquid Precipitation.

IF there is but a few half-Ounces of Copper in a Centner of the Pyrites; they can never be found out by a Precipitation by Fusion: For so small a Quantity of Copper dispersed among so great a Heap of heterogeneous Matter, is unavoidably burnt away by so many repeated Roastings and Fusions. Wherefore, a Method must be chosen, whereby the Copper may be separated from the Ore by Means of liquid *Menstrua*, and then again easily precipitated. The Acid of Sulphur, which is already in great Plenty in Pyrites, is very proper for this Operation. Make a Solution of Vitriol out of such an Ore, by a light Roasting in an open Fire, and by exposing it afterwards to an Air somewhat moist, and pouring warm Water upon it: Next, put into this Solution small Iron-Plates, extremely well polished, and perfectly clean of all Grease. If there is any small Quantity of Copper in the Pyrites, it will certainly stick close to the Iron-Plates, in Form of a very subtile Powder, of a deep yellow Colour, and all of it will be fetched out of the Solution, if you have but Time enough, and a moderate Warmth: Of which more hereafter, when we treat of Vitriol. By this Means, the very

least Quantity of Copper is detected in Iron, when you make well saturated Vitriol, with Spirit of Vitriol diluted and perfectly pure. The same may also be done with several metallick Mixtures, in which Copper enters: But it would be too long here to mention the several Methods to be observed in this Case; and the Person that makes the Operation will easily find them out.

PROCESS XLVIII.

The Separation of Silver and Copper by Fusion with Lead.

LET the Copper be freed of all heterogeneous Matters, by the Methods prescribed in the foregoing Processes: But the Gold and Silver being much more constant than Copper itself, remain therein in the foregoing Operations. But, the Copper must be tried, before it is intirely melted, to know whether the Quantity of Gold and Silver it contains, will repay the Charges of the Separation. For, this Separation must be made with Copper still impure, called black Copper, by way of Fusion with Lead: Because this Separation does not succeed as well with melted Copper; See the Reason of this (*Part I.* § 468, 469). Besides, any Portion of the Lead remaining in the Copper after the Eliquation, renders the Melting of the Copper more perfect and easy, than if it was performed without Lead. It will not be improper, to give a short Exposition of the Reasons of this Process: But whoever is desirous to know the several and peculiar Furnaces, Machines, and Ways of proceeding, fit for this Purpose, let him pursue the Writings of *Ercker* *, *Agricola* †, and others, whose Methods have been rectified by a certain Au-

* Translated into *English* by Sir John Pettus, under the Title of *Fleta Minor*: Or the Laws of Art and Nature, in knowing, assaying, &c. of Metals, *Lond.* 1686. in Folio.

† *De re Metallica*, Libb. XII. *Basil.* 1621. in Folio.

thor ina Treatise Vom Seigereu und Erzt. Beitzten. But Mr. Swedenborge has collected all these Things †. This Separation is performed chiefly by two Operations; viz. a just proportioning the Mixture with Lead, and the running off the Lead, from the Gold and Silver dissolved by it. As the Lead is not perfectly separated from the Copper by Fusion, but there remains a Quantity of it adhering to the Copper (*Proc. XXXV*), and there remains also some Gold and Silver in the Copper, according to the Quantity of the remaining Lead; for this Reason, the Silver and Gold ought to be diluted in such a Quantity of Lead, that in that Portion of Lead, which cannot be run off, so small a Quantity of the above-mentioned Metals may remain dissolved, as doth not deserve the Addition of more Lead. You are to observe, that, in the Computation of the Expences, you must have Regard to the Loss of Lead and Copper; since it is self-evident, that Part of these Metals must be lost in the Course of this Process. You are likewise to examine with the same Exactness as in the Copper, by coppelling, what Quantity of Silver there is in the Lead wherewith the Separation is to be made: For, it is the same Thing whether Silver and Gold were already in the Lead which is to be melted down, or whether they have been received by it out of the Copper, in the Fusion of it with the Lead. Finally, a certain Proportion is required between the Lead and the Copper; for, if the Lead exceeds ever so little the quadruple Quantity of the Copper, you will hardly avoid the falling of the latter into small Bits, and a great Deal of it is carried away by the melted Lead. For this Reason, likewise, you are to add to your Copper, which is easy to be melted by itself, as well as with

† In his great Work called *Emanuelis Swedenborgii Principia Rerum naturalium, sive novorum Terminum Phænomena mundi Elementaris Pbn. J. p. pice eximandi. Dresdæ & Lipsiæ 1734*, in 3 Tom. in Fol.

Lead, some crude Copper containing Iron, and which is difficult to be run down either by itself or with Lead, and this chiefly, when your Copper is so rich in Silver and Gold, that it requires a considerable Addition of Lead for a sufficient Fusion. Neither are you to add much less Lead to your Copper than twice and a half the Quantity of it: Because, if you diminish the Proportion to an Excess, there remains behind as much Lead, as is run off. But, they most commonly add as many Portions of Lead, weighing 17 *lb.* each, as there are half-Ounces of Silver and Gold in the Mixture of Copper and Lead, after the melting of them together: However, you subtract as much from these taken together, as the Copper contained Lead before: By this Means, you may separate out of one Centner of Copper, one Ounce, or even one half-Ounce of Silver. Now, if there are in your Copper so many half-Ounces of Silver, that as many Portions of seventeen Pounds weight of the superadded Lead, exceed the quadruple Quantity of the Copper; this Copper must be mixt with Copper that is poor, or made such, to obtain a just Proportion, or it must go twice through this Process. But, when the Copper is rich, and there are no Obstacles in other Respects, they use Litharge in great Part instead of Lead, and substitute 125 *lb.* of it, for 100 *lb.* of Lead: For you will get that Quantity of Lead from it by Reduction. They even also take the Scoria's remaining in the Tests, which differ from Litharge only in Purity, and which pass through the reducing Furnace together with the Copper, while this is melted. The Cakes or Loaves which are made of this Mixture, commonly do not contain above three Quarters of a Centner of Copper, and two or three Centners of Lead.

A great Quantity of Lead is melted out of these Cakes, first by a gentle flaming Fire, and Silver is afterwards separated from it in a Test. But the Lead remaining of these Cakes is separated in a
Furnace,

Furnace, which admits a Draught of Air somewhat stronger, and a great Deal of the Copper falls from the Cakes along with it. These Matters lastly melted out, are commonly added in the Allays of other Copper. You will find several Examples, and Methods of proceeding, in the above-mentioned Authors.

OF TIN.

PROCESS XLIX.

The Roasting of Tin-Ore

APPARATUS.

ROAST a determined Weight, for Instance, six Centners of Tin-Ore pounded to a Powder not over fine, in a Test, under a Muffle thoroughly red-hot, shutting first the Vessel for a few Minutes, and then opening it. For the Melting of this Ore does not require a stronger Degree of Fire, than the foregoing Copper and Lead-Ores. If your Fire is pretty strong, you will see a volatile Part of it expelled in Form of a white Smoak, of the unpleasant Smell of Garlick: When this is over, take out the Test, and when the Ore is grown cold, beat it anew, and roast it a second Time in a Fire somewhat stronger; till you no longer perceive any arsenical Fumes: Which is better detected by the Smell, when you take it out, than by the Sight of it; or if you will not make this Trial, put upon the red-hot Test, when taken out of the Fire, a thick, cold Plate of Iron, and look at the inferior Surface of it before it is grown very hot; this will be covered with a small whitish Cloud, if the Metal still exhales any Arsenick.

The

The Use and Reasons of the Process.

1. Tin-Ore is never found charged with Sulphur, but disposed into a State of Ore by Arsenick: It is chiefly white, semidiaphanous, and on the Out-side resembles in some Measure Spaad, or the white *Stalactites*. But the Sulphur, which is of a dark Colour in Tin-Ores, is hardly worth any Consideration with regard to its Arsenick. Now, as Arsenick carries away a great Deal of Tin by the Fire, and soon resolves Tin into Ashes, and destroys the rest of it, reducing it to a brittle Body, looking like a Semi-Metal; it is necessary to free every Tin-Ore from its Arsenick, as perfectly as possible, by roasting. But the longer this Ore is in melting in a strong Fire, the easier a great Part of it is burnt, so as not to be reducible, and so as to turn to a pretty refractory Scoria in a reducing Fire. Besides, Tin is never got so good out of an Ore too long agitated by the Fire, as when the just Time and Strength of the Fire are observed. The same may be experienced with some of the best Tin already reduced: For the oftner it is reduced and burnt to Ashes, or the longer the Ashes are tormented by a strong and pure Fire, the worse your Tin will constantly prove after the Reduction,

PROCESS.

The Washing of Tin-Ore, and its farther Preparation for a Reduction.

APPARATUS.

TIN-ORE, which surpasses the Ores of all other Metals in specifick Gravity, admits likewise more washing than any of them. You may, by Elutriation, separate from the Tin-Ore, not only Earths and Stones, but also other Ores specifically lighter than itself; especially Copper and Iron-Ores,

and

and among these chiefly the light pyritose ones. But the Washing of the other Ores succeeds likewise the better, because the Tin-Ore is not so easily comminuted to a fine Powder, as the other Ores are; except, however, Iron-Ores, which are the most rigid and hardest of them all. The Tin-Ore is always found of a solid * Figure, and when pounded, it always retains a † solid granulated Form. This Ore will sometimes bear a pretty strong Roasting, without falling into small Bits on this Account. Therefore, when hard, ponderous Stones are to be washed off, it will be no Detriment to the Tin-Ore, if they are previously disposed by Fire for an easy Comminution. Nor do the interspersed Pyrites turn less into a light dusty *Caput Mortuum*, when the Roasting is but gentle at first, and repeated several Times: Whereby the Copper and Iron-Particles, are afterwards easily washed off by Elutriation. But if there remains a hard, more intricate, ponderous Iron-Ore, not easy to be calcined, it is extracted with the Load-stone after the Roasting and the Elutriation. But the Separation of the Copper-Ores, and of the Iron pyritose Ones from the Tin-Ore before the melting, is the more to be regarded, because none are found mixt with the Tin-Ores so frequently as these: But as Tin dissolves Iron and Copper, and even with a Fire much milder than is required to make them melt of themselves; it is easy to conceive, that all is confounded, when a reducing Fusion is made, before the Separation of both by Elutriation or by the Load-stone has been previously made: Whence the Consistence of the Tin thereby produced, is spoiled, and it is rendered unfit for a great many Uses. But a most exact Separation of the Earths and Stones from the Tin-Ore, is required; because reduced Tin can never sustain so strong and long-lasting a Fire, as is required to perfect a sufficient Scorification for

* A cubic Figure.

† A cubic Figure, even when granulated.

the Precipitation of the metallick Particles. Likewise, the Calx itself of reduced Tin, renders all the Scoria refractory and clammy in the Fire.

PROCESS LI.

The Reduction of Tin-Ore in a close Vessel.

A P P A R A T U S.

THIS Process is done in the same Manner, as the like with the Lead-Ore (*Proc. XXX*); only let the Fire be carried as soon as possible to the highest Degree which is necessary here; and so soon as you judge that the Flux is melted, take out the Vessel, let it grow cold of itself, break it, and examine the Scoria and the *Regulus*.

The Use and Reasons of the Process.

The Examination of all Metals that are destructible in the Fire, and above all that of Tin by Precipitation and Reduction in close Vessels, is extremely deceitful; insomuch that the most experienced Assayer, will most rarely find *Regulus's* of a perfectly equal Weight, from one and the same Ore, though it be comminuted, and all the Particles well mixt together, if he makes this Process several Times over: For, the Ore or Calx of Tin, is refractory enough, when a Reduction is to be completed; wherefore, it requires a more violent Fire: But, reduced Tin, on the contrary, is most quickly destroyed again by the same Fire. You may, indeed, in some Measure judge, whether an Ore is rich, poor, or middling; but you can hardly do it to a Pound: For, during the Operation, you have no certain Sign, whether the Reduction and Precipitation are perfect, or no: And have only meer Conjectures as to that. The saline Flux, which helps the Scorification, has nothing to convert into Scoria but the
Tin

Tin itself : For, the terrestrial adherent Particles, are separated with greater Care, and more perfectly from the Tin-Ore, than from the others (*Proc. L.*). Nevertheless, you may know from the perfect or imperfect saline Scoria, from the small metallick Grains dispersed among the Scoria, or even from the very Scoria proceeding from the destroyed Metal, which may be reduced again, but chiefly from that part next the metallick *Regulus*, whether a great Fault has been committed. Therefore, the Examination of the Tin-Ore is better done by the following Method.

P R O C E S S LII.

The Reduction of Tin-Ore, ex tempore.

A P P A R A T U S.

1. **C**HUSE a large *, thick, extinguished, and well burnt Coal of soft Wood, not very fibrous, nor crackling in the Fire, such as lime-tree or halle-tree Wood : Make the largest Surface of it flat and smooth with a Knife. Excavate in that Plane a Channel open in the fore-Part and above, beginning at the Side and reaching to the Middle of the Plane : Make a small pretty deep Pit at the hinder Extremity of this Channel : But, the Capacity of both the Channel and the Pit must be so great, as that some docimaistical Centners of the Ore, may hardly fill the third Part of both.

2. Put into the above-described Channel (N^o. 1.) two docimaistical Centners of Tin-Ore, well prepared, and beaten to a most subtile Powder, with a little of common Pitch, and let them be spread so wide, that the Ore thus heaped up, may no where come up to the Height of the Channel. Put upon this Coal another, of equal Length and Breadth, and made smooth in such Manner, that the Channel and

* Or a large Piece of unlighted Charcoal.

small Pit may be both quite covered over. Make in the Place where the Channel and small Pit are contiguous to the upper-Coal, a small Hole through the whole Thickness of it. Then join both Coals together with an Iron-Wire, or with Lute applied at the Joints.

3. Put this *Apparatus* upon Ashes or Sand, that it may not vacillate, and in a declining Situation, that the Aperture of the Channel may be uppermost, and look towards the Assayer, and the back-Part, where the small Pit is, be much lower. Then, surround it on all Parts with black and burning Coals; in such Manner however, that the Passage of the Wind through the Channel before, may not be intercepted. Now, if you blow the Fire with a Pair of hand-Bellows, so as that the Blast may enter directly into the open Extremity of the Channel, and again go out through the Hole made in the upper-Coal, the Flame following the same Direction, soon melts the Ore in the Channel, and reduces it at the same Time: Which is also helped on by the Pitch. But so soon as the Ore is in Fusion, the Metal runs into the same Pit, where it is free from the great Violence of the Fire. This done (which is perceived by Sight, or felt by a small Iron-Wire) remove the burning Coals around, and with a small Brush sprinkle it softly, and Drop by Drop with Water; that the *Regulus* of Tin may indeed be quickly cooled, but not dissipated in Grains.

P R O C E S S LIII.

To reduce Tin-Ore, by a Stratification with Coals

A P P A R A T U S.

YOU must here observe all that has been said of a like Process (XXXIV.) with Lead: Provided the Ore be well prepared, and the Bellows be not so much directed downwards towards the Bed, nor blowing
so

strongly. Let the Coals be small, and of a soft Wood, that a pretty strong Fire may be most quickly kindled, and extinguished soon. For, if small Coals are agitated with Bellows, they grow red-hot, and are consumed much sooner than the large ones; and if you sprinkle them here and there with Water drop by drop with a small Broom, the Fire grows of the utmost Strength: For which Purpose, likewise, you may put moistened Ore into the Fire.

O F I R O N.

P R O C E S S L I V.

To reduce and precipitate Iron out of its Ore, in a close Vessel.

WE have already mentioned, how the martial Earth and the Iron-Ore may be known by the Action of the Magnet (*Part I. § 359, 360.*) but it is plain from what follows, that this Examination is upon no Account sufficient. For, all Metals, Semi-Metals, Sulphur, and Arsenick, except only Antimony and Lead (which last is not to be considered, because it never admits of any Mixture of Iron) being united in great Quantity with Iron by Fire, hinder not the Magnet from attracting the Iron. (*Vid. Cl. Henckelii pyritolog. pag. 413.*) And though the Action of the Load-stone is the weaker upon Iron, as there is a greater Quantity of the Minerals just mentioned joined with it, and *vice versa*; nevertheless, we can upon no Account conclude from the strong or weak Action of the Magnet, what Quantity of Iron can be reduced out of the Ore, or out of any other martial Compound: Because the various Strength of Load-stones, and the Quality and Proportion of the several Bodies that may be combined with Iron, occasions a very great Difference among the Effects of the Magnet: For more may be mixt of one Body with Iron, than of another,

ther, so that a Mass cannot be attracted with equal Strength by the Load-stone. The easier and more difficult melting of Iron, and its Quality, when melted, likewise do depend upon these kinds of Mixtures. Besides, the Bodies which are contiguous to Iron only on the Outside, are partly taken up along with it by the Load-stone, let the Iron or its Ore be ever so finely pulverized. For this Reason, you must have Recourse to an Examination by Fire, to know with Certainty the Quantity and Quality of the Iron to be reduced out of the Ore.

A P P A R A T U S.

1. Roast for a few Minutes, in a Test under the Muffle, and with a pretty strong Fire, two Centners of the small Weight of your Iron-Ore grossly pulverized: That the Volatiles may be dissipated in Part, and the Ore itself be softened, in case it should be too hard. When it is grown cold, beat it extremely fine, and roast it a second Time, as you do the Copper-Ore, but in a much stronger Fire; till it no longer emits any Smell: Then let it grow cold again.

2. Compose a Flux of three Parts of the white Flux (*Part I. § 163*), with one Part of fusible pulverized Glass, or of the like sterile unfulphureous Scoria's; and add Sandiver and coal-Dust of each one half-Part. Add of this Flux three Times the Quantity of your roasted Ore, and mix the whole very well together. Then chuse a very good Crucible, well rubbed with Lute within, to stop the Pores which may be here and there unseen; put into it your Ore mixt with the Flux; cover it over with common Salt, and shut it close with a Tile, and with Lute applied to the Joints.

3. Put the wind-Furnace upon its bottom-Part, having a Bed made of coal-Dust (*Part I. Plate III. Fig. X*): Introduce, besides, into the Furnace a small Grate supported on its Iron Bars, and a Stone upon

upon it, whereon the Crucible may stand as upon a Support. Surround the Whole with hard Coals not very large, and light them at Top. When the Vessel begins to grow red, which is indicated by the common Salt's ceasing to crackle, stop with gross * Lute the Holes of the bottom-Part, except that in which the Nozel of the Bellows is received: Blow the Fire, and excite it with great Force, adding now and then fresh Fuel; that the Vessel may never be naked at Top. Having thus continued your Fire in its full Strength for three Quarters of an Hour, or for a whole Hour, take next the Vessel out of it, and strike several Times the Pavement, upon which it is set, that the small Grains of Iron which happen to be dispersed, may be collected into a *Regulus*, which you will find after having broken the Vessel.

4. When the *Regulus* is weighed, try its Malleability; then make it red-hot, and, when so, strike it with a Hammer; if it bears the Strokes of the Hammer, both when cold and when red-hot, and extends a little; you may pronounce your Iron very good: But if, when either cold or hot, or in both States, it happens to prove brittle, you may judge it not to be quite pure, but still in a Semi-mineral Condition. But, the worse the Characteristics of your Iron are, the greater the small Grains or Furrows will be found in it when broken, which is called in German † *Grob-Koornig*, *Grob-Speissig*. Whence the Workmen, at the Sight of broken Iron, use to judge of its Goodness, though not with demonstrative Certainty.

The Use and Reasons of the Process.

1. Before you reduce your Iron-Ore by Fire, the Arsenick, but much more the Sulphur, must be dissipated at least in Part: For the former renders the

* Or Windsor-Loam.

† Coarse grained, coarse fibred.

Iron, that comes out of the Ore, brittle, and, the latter not only does the same, but being managed in a close Vessel, with a saline alkaline Flux, turns to Liver of Sulphur, to the Action of which Iron yielding in every Respect, it can upon no Account be precipitated, and, if not the whole, a great Part of it, at least, is retained by the sulphureous Scoria; so that in this Case, you will most commonly look in vain for a *Regulus*. See the Effect of the Ingredients, of which the Flux is composed (*Part I.* § 164).

2. The Iron which is obtained from this first Precipitation, has hardly ever the requisite Ductility; but is rather brittle: The Reason of which is, that the Sulphur and Arsenick remain in it. It is true, when a Vein of Iron is roasted, if it abounds in both these Matters, it loses the greatest Part of them, and even the more so, as the Ore is less disposed to melting: But, some Part of them seems to be so strictly inherent in the Ore, that it can never be separated, but with absorbent, terrestrial, alkaline Ingredients, that change the Nature of the Sulphur: For this Reason, in a larger Operation, they add quick-Lime, or marble Stones that turn into an acrid Calx, which, while they absorb the said Minerals, are by it, and by the Help of the destroyed Part of the Iron, brought to a Fusion, and turn to a vitrified Scoria; though, at other Times, they resist so much by their own Nature a Vitrification. Another cause of the Brittleness of Iron is the unmetallick Earth, when it is not yet separated from it: For the Iron-Ore contains a great Quantity of it, and in the melting remains joined with the reguline Part: Whence the Iron is rendered very coarse and brittle. Some Iron-Ores are altogether untractable: Nevertheless, the *Regulus's* produced out of them, when broken, have sometimes a neat Semi-metallick Look: Which proceeds undoubtedly from a Mixture of a small Quantity of some other Metal or Semi-Metal. But they generally neglect a further Examination of these Sorts of Mixtures, and the Methods of separating

rating them, which are certainly difficult; because we find almost every where Iron-Ores, that are both richer, and of a better Kind.

3. This Fusion and Reduction of the Iron-Ore by Stratification with Charcoal, succeeds with great Difficulty in a small portable *Apparatus*: For, before the Iron-Ore can be put into the Fire, the Walls of the Furnace must be very red-hot: Which cannot be done without some Detriment to the *Apparatus*, unless the Inside be done over with thick Lute*. Besides, if the Lute is not of the best Kind, it is almost consumed by so violent a Fire, and by the Scoria's, as are likewise the Walls of the Furnace. It is better, for this Experiment to make a small Furnace with Stones, in the Hearth of a Smith's Forge; then the Operation is finished in the same Manner, as a like Process with Copper. Nevertheless, a still more violent Fire is required here; and Scoria's of Iron, or some other very fusible Stones, sometimes together with Lime, must be put into the Furnace before and with the Ore to be tried; not only to promote the Melting, and to separate the Iron from the heterogeneous Bodies, but also that these Things swimming upon the *Regulus*, may hinder its being consumed by the Fire and the Blast. The Furnace must be kept very full with Coals during the Operation, and but a small Quantity of the Ore be put in at a Time.

PROCESS LV.

The melting of crude brittle Iron, to make it malleable.

TO restore Malleability to Iron, the Bodies which render it brittle must be separated, and the Particles of it be made to stick closer to each other, that every heterogeneous Matter, lying hidden in its Interstices, may be expelled. This may be conveniently done on a Hearth like that of a Smith's Forge, having a Bed

* Of Windsor-Loam.

made with coal-Dust: Put into this Bed the Coals and the Iron to be melted, heaped up in good Quantity in *Strata*, then with the Bellows blow the Fire pretty strongly, that the Iron may be brought to a Fusion: And if it does not melt soon of itself, and emit Abundance of Scoria's, it is necessary to help on the Fusion with fusible Scoria's, or with Sand. Let the Fire be not much greater than is necessary to make all these Matters melt as equally as possible: Let the melted Mass be agitated here and there, that all the Parts of it may feel the Action of the Fire and Air equally: And let the increasing Scoria's be taken out at one or two Times. In the mean Time, a great many Sparkles, like Rain, will be thrown out from the Iron, which diminish the more, as the Iron comes nearer to the desired Degree of Purity, but they never cease intirely. Then let the burning Coals be removed, and the Scoria's be conveyed out of the Fire, through a Channel made for that Purpose; but, when the Iron grows solid, let it be taken red-hot out of the Fire, and tried by striking it with a Hammer: If it proves crude still, let the melting be repeated: And when at last sufficiently purified, let it be hammered, and extended several Ways, by making it red-hot many Times over: This done it will no longer be brittle, even when cold.

The Use and Reasons of the Process.

The remaining volatile Materials which make Iron brittle, and keep it in a mineral State, are dissipated in this Operation by the Fire and Air; the terrestrial, unmetallick, vitrified Parts, are rejected under the Form of Scoria's, while the Iron is in a perfect State of Fusion: Nor can this, however, be done with sufficient Exactness by a single Fusion: Nay, Iron does not even acquire its desired Degree or Malleability by a second Fusion alone, but when cold, and strongly hammered, it flies asunder, or at least cracks; for which Reason it must be hammered several Times,

Times, by making it very red-hot over and over again; that the remaining terrestrial, scorified Parts, may be expelled out of its Interstices, and the metallick Particles be united together. This is called in German *Durchschweißen*: And when the Operation is well performed, it communicates to Iron, whether red-hot or cold, its due Malleability. It is observable here, that any Iron, though ever so pure, is perfectly malleable, when melted in a reducing Fire; but yields with Difficulty to the Hammer immediately after the Fusion. It likewise becomes rigid, if suddenly cooled, especially if it is immersed in Water: However, this Rigidity happens only in cold Weather, and is not so great as that of melted crude Iron, and may be perfectly reduced to its first State, if, after having been red-hot for a few Hours in a pure gentle Fire, it cools of itself very slowly. Nay, other hard Metals, such as Copper, Brasses, Silver, and Gold, harden after the Fusion, or after having been beaten over and over with the Hammer, but never to such a Degree as Iron, and their Flexibleness is restored by the same Artifice, that is, by being made red-hot, and cooled by very slow Degrees; so that they afterwards grow almost as pliant as Lead. But you must take Care that there is no smoaking Flame proceeding chiefly from the cruder Charcoals, otherwise the Softening does not succeed. This may be observed chiefly in Gold, which, though very pliant and tenacious, yet becomes more rigid than Copper, when an extinguished Charcoal, still smoaking, and half burnt, falls into it, while it is perfectly red-hot, or melted in a Crucible.

As for the rest, you must observe here, that there is no Metal, that suffers so great a Diminution of its Substance in the Excoction, or only in a simple Fusion, as Iron does: Nay, if only made very bright red-hot, it burns away most speedily, or cleaves into scorified Scales. But this Combustion happens

quicker in malleable purified Iron, than in Iron to which Sulphur has been added.

PROCESS LVI.

The Preparation of Steel out of Iron, by Cementation.

STEEL is made of Iron in two different Manners, viz. by Cementation (*Part I* § 459.), or by Fusion. The Cementation is performed in the following Manner.

A P P A R A T U S.

I. Chuse some Barrs of pure Iron, not over-thick, and quite free from heterogeneous Matters, the Flexibleness of it, both when hot and when cold, is a very good Sign thereof. Prepare a Cement composed of such Ingredients as emit an abundant Phlogiston, when agitated by the Fire, provided the said Phlogiston be altogether free from the sulphureous mineral Acid: Such as are all extinguished Coals, and in short all Parts of Animals and Vegetables; among which, those, however, are much so, which contain a greater Quantity of Oil in them, and which being freed of an excessive Phlegm, have been burnt before into a Semi-carbonaceous Mass. Avoid whatever absorbs oily Vapours with great Force, or even spreads the Acid of Sulphur, or the mineral Sulphur itself. It is better to add a few Compositions, in Order to clear the Matter.

Take Charcoal-dust moderately pulverised 1 Pt. of Wood-ashes $\frac{1}{2}$ Pt. Mix them together.

Take Charcoal-dust 2 Pts. Bones, Horns, Leather, Hairs of Animals (it is all one if you use but one, or several, or even all of them mixt together; for one of them alone is as sufficient as the Mixture of them all) burnt with a gentle Fire till they are black in a close Vessel, then pulverise them 1 Pt. Wood-ashes $\frac{1}{2}$ Pt. Mix them together.

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As for the rest, it has been found, that the Parts of Animals, on Account of the Abundance of Oil they contain, are of a quicker Effect than the rest.

2. Prepare an Earthen-vessel, the best Figure of which is the Cylindrical, two or three Inches higher than the Iron-bars (N^o. 1.) are long: Put into the Bottom of it your Cement prepared in the aforesaid Manner, so that being gently pressed down, it may cover the Bottom of the Vessel to the Height of one Inch and a half. Place the Iron-bars perpendicularly, in such Manner, that they may be about one Inch distant from the Sides of the Vessel, and from each other: Fill the empty Interstices with the same Cement; and cover also the Bars with it, that the Vessel may be quite full; next cover it with a Tile, and stop the Joints with thin Lute.

3. When thus prepared (N^o. 2.) put this Vessel in a Furnace, where you may for several Hours maintain an equal Fire, as either in the Bottom of the Tower, or in the first Chamber of the Athanor (*Part I. § 243.*) Make a Fire so strong, as that the Vessel may be moderately red-hot for six or ten Hours together: When this Time is over, take it out of the Fire, and dip the red Iron-bars into cold Water. They will then be brittle, and turned to Steel, there will appear no Scoria at the Out-side, nor will the Weight be diminished, if you have but rightly made your Process according to the Regimen of the Fire.

4. The Signs of the Iron's being changed into Steel are, if being red-hot, and extinguished in cold Water, it becomes very hard, not yielding to the Hammer, brittle when more strongly hammered, and resisting the hardest File: By which Quality it is distinguished from Iron rendered malleable, which indeed grows rigid when extinguished in Water, but yet retains a considerable Degree of Ductility in the Cold, and may be extended in all Dimensions with the Hammer. However, Steel that is cooled softly, and by slow Degrees, may be filed and extended with
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the Hammer any Way, some more, some less: By which Quality it may be distinguished from crude melted Iron: For this is often brittle, both when cold and when hot, though it has not been extinguished in Water. But, there are a vast many Degrees in the hardening of Steel: For, if it has been made too red-hot, and is suddenly extinguished in cold Water in Motion, it hardens more than if it had been but faintly red, and cooled in warm Water. This Hardening is caused by all such Bodies as suddenly absorb the Heat, and at the same Time do not easily penetrate the Steel, but change its Nature. Steel is moreover of a darker Colour, and the Surface of it, when broken, appears to consist of smaller granulated, and even striated Particles, than the Iron which it is made of: The Germans call it * *Klar-Kornig, Klar-Speissig*. But, this appears more distinctly, when Steel is welded to the same Kind of Iron, which it was made of, and when the Mass made red-hot is well incorporated together, by hammering: If then you harden it again by extinguishing it in cold Water, and polish it, the Veins of Iron may be very well distinguished from those of Steel: For, the Iron-ones are more whitish, and almost of a Silver-colour; but the Steel-ones of a darker Dye, and almost of the Colour of Water. For which Reason Dr. *Stahl* is of Opinion, that the Steel of *Damascus*, which has the same Colour on the Out-side, is made in the same Manner. But, if such Steel mixt with Iron is broken, you may likewise observe the Difference of the Largeness and Colour of its Particles.

The Use and Reasons of the Process.

1. All you do in this Operation is, to apply oily Vapours to pure Iron, the rigid Body of which being mollified by the Heat, and made quite red-hot, is penetrated by the said Vapours, which then strictly

* Fine grained, fine fibred.

unite to it: Which is thought to be so, because the Iron thus changed, not only preserves its first Weight (whereas when made red hot, it otherwise loses always a great Quantity of its Substance; which goes away in Form of scaly Scoria's) but even proves to have increased it a small Matter, unless too great and long-lasting a Fire has burnt the Surface of it; which the Scales going off from it do shew. For this Reason, the essential Difference between pure Iron and Steel, consists in the greater Proportion of Phlogiston more intimately joined to one than to the other. Thence the Reason is likewise clear, why a too thick Piece of Iron being put into such a Cement, or the Iron-bars not being left long enough in the Fire with the Cement, they are only surrounded with a steely Crust, while the inward Substance remains Iron.

2. That every oily Substance free from the Acid of Sulphur, is fit for changing Iron into Steel, is plain from the several Experiments of Workmen, some of which use for their Cements a Multitude of different Particles of the animal and vegetable Kingdoms, and yet all of them produce the very same Kind of Steel, provided the other Ingredients are alike: But if you employ for your Cement any Body exhaling Acid of Sulphur, or even Sulphur itself in a strong Fire, you not only will have no Steel, but instead of it the Substance of the Iron changes, and goes away into a Scoria. For this Reason Sea-coals * are not fit to render Iron malleable, nor to turn it into Steel: Nay, Iron and Steel are more easily burnt and destroyed by them, than they are by an open Fire

* Our Sea-coals or *Newcastle Coals*, or in general all the fossil Coals which cake in burning and run into Cinders, abound with Sulphur, and therefore are improper to be used about Iron, always making it brittle; but Pit coals, Kennel-coals, and Scotch-coals, which burn to a White-ash like Wood, and abound more in a Bitumen, may be used in the first fluxing of the Iron from the Ore, and if the Iron prove not so malleable as is required, this Property may be given to it by melting the Metal a second Time with Wood.

of Wood-coal, unless you use a peculiar Remedy for it.

3. Therefore, the best Steel made red hot a long Time, or frequently, especially in an open Fire, the phlogistick Part being dissipated, turns to Iron again, provided the Fire is managed, so as that it may not quickly turn the whole Mass into Scoria's.

P R O C E S S LVII.

The Production of Steel out of crude unmalleable Iron, or out of its Ore, by Fusion.

WE shall here in a clear and general Manner give the Method for making Steel by Fusion. Chuse for Instance, Iron-Ore, or the Iron itself still crude of the first Fusion, which we know can be rendered tough and firm by being melted, made red hot, and hammered. For, according as Iron, or its Ore is different in its Kind, so you may make with it different Sorts of Steel, and with greater or less Ease, or Difficulty. Put at one or several Times into a Bed made with Charcoal Dust in a Smith's Forge, such Quantity of this Metal divided into small Parcels, as that the Metal remaining after the Melting of it is compleatly performed, may not be more than two or three common Centners; not only that the Melting may be sooner finished, but also because a small Mass may be better and more equally penetrated with the Vapours of the Phlogiston: Nay, they also add, as a defensive Menstruum, some of the vitrescent fusible Scoria's, either of Sand, or of small Stones of the same Nature: Then put upon them Abundance of Charcoal, light them, and admit only a gentle Blast of the Bellows; that the Scoria's and the Metal may both melt very well: Take out now and then Part of the Scoria's, and often stir the melted Mass with a Stick; that all the Parts of it may as much as possible feel the same Degree of Fire. Having at last removed the Fire and the Scoria's,

ria's, and the Mass being grown solid, put it upon an Anvil, and with a Hammer divide it into two Parts, which must be extended into long Bars by being made red-hot, and hammered several Times over: Then extinguish them in cold Water, whereby they are rendered so very hard, that they will fly asunder when struck with great Force, and will not be flable; which shews that the Operation has been well made. But, if you have a Mind at the first Time to change Iron-Ore or crude Iron into Steel, nothing but a Repetition of Trials will inform you, how long and at how many Times the Matter in Hand must be melted, made red-hot, and hammered. For, there are Ores, which, by a first Fusion, produce Masses which are intermediate between malleable Iron and Steel; or resemble Steel that is but half-Worked: Whence such Steel-Ores are commonly called by the Germans * *Stahl-Stein*. Other Ores, on the contrary, must often go through a Number of long-lasting Fusions and Hammerings, and sometimes lose half the Weight of the crude Iron in the first Fusion, and yet never yield a right Kind of Steel. But, it is easy to guess at the Reason, why this Process is very much forwarded, when you now and then add to your burning Coals, a fat, oily, and fixt Fewel, taken out of the animal or the vegetable Kingdom: For, the Metal must be penetrated by the Phlogiston, and receive it both in great Plenty and very intimately: While, at the same Time, the terrestrial and sulphureous Particles which render the Iron crude and brittle, are dissipated: For, the above-mentioned Fewel produces Nothing of these Matters, but only constantly supplies a Phlogiston destitute of Acid of Sulphur. Take Care, on the contrary, not to torture your Metal with too violent, too long, and too dry a Fire, nor with an excessive Blast of Wind: Otherwise, you would in vain expect the desired Change.

* Steel Stone.

By this Means, you will prepare a good Quantity of common Steel, fit for Sale: If any Reader is desirous to have any more particular Apparatus's, such as are practised in several Places, he will find many of them, though no Way essentially different among themselves, in *Swedenborges's Treatise of Iron* †.

O F M E R C U R Y.

P R O C E S S L V I I I.

The Separation of Mercury out of an un-sulphureous Ore, by Distillation.

A P P A R A T U S.

1. **T**AKE a Lump of the pulverized Ore, one common Pound, which must stand for one Centner; put it into a Glass Retort perfectly clean, well loricated, or coated up, to half the Length of its Neck: This must be very long, and turned backwards with such a Declivity, that a Glass-Recipient may be perpendicularly applied to it. But, you must chuse a Retort small enough, that the Belly of it may be filled hardly two Thirds by the Ore. This Retort must be placed so, as that nothing of the Fluid adherent to the Neck of it may fall into the Cavity of the Belly, but that the Whole may run forward into the Recipient: Therefore, unless the Pavement of the Hearth is already high, make one *ex tempore* with Bricks, or with an Iron-plate, put upon a Trevet or some other high Support: It is enough if the Area of it is one Foot square. In the Middle of the Hearth, put a small Heap of Sand, to set the Retort upon, lest it should vacillate. But, the Neck must be supported, at the Place where it is nearest to the Belly, with a square Stone of a proper Height, placed

† In the Work cited, p. 329.

And in that most curious and elaborate Work of Mr. Reaumer, entitled, *L'Art de convertir le fer forgé en Acier*. 4to.

at the Extremity of the Hearth, which will at the same Time hinder the Heat from affecting the Glass-Recipient. Finally have a small Recipient, full of cold Water; let it be perpendicularly situated, and receive the Neck of the Retort in such Manner, that the Extremity of it be hardly one half-inch immersed into the Water; as for the rest, it is not necessary to stop the Joints.

2. Let the Retort be surrounded with hot burning Coals, placed at some Distance, in Form of a Circle lest the Vessel should burst by too sudden a Heat. Then by Degrees bring the burning Coals nearer and nearer, and at last surround the whole Retort with them and with fresh Charcoal: that it may grow slightly red-hot. This Fire having been continued for an Hour, let the Retort cool of itself. Then strike the Neck of it gently, that the large Drops which are always adherent to it, may fall into the Recipient: When the Recipient is taken away, wipe off with a Pencil the remaining smaller Drops, and collect them in a low open Vessel set under, leaving mean-while the Retort in its first Situation. Add this Portion of Mercury to the other already collected in the Recipient. Let the Water be well shaken first, and decanted, and the Mercury be poured into a Filtrum, made of a two-fold filtrating Paper; that the superfluous Moisture may be absorbed; and then weigh it in a Glass-Vessel.

3. If you have at Hand a Furnace having a Sand-bath, this Process will be much more easily performed; but the Pot which contains the Sand must be middling red-hot, and the Retort be able to touch the Bottom of it immediately, nor is it then necessary that the Retort be loricated.

Another Method, by Descent.

When the Apparatus for the lateral Distillation (N^o. 2.) is wanting, you may easily procure an Apparatus by Descent. *Viz.* Chuse two Earthen Pots, or

melting

melting Vessels, the Orifices of which must be of equal Diameter. Then adapt an Iron-plate to the Orifice of one of the two Pots in such Manner, that it may indeed rest upon the Brink of it, but not jut out too much all round: Let this Vessel have several Holes bored here and there in it. Put it on the Pavement of the Hearth; pour into it pure Water about two Inches high; then shut it with the Iron-plate. Put upon this Plate a small Vessel of a lesser Capacity, and full of a *Matrix* that contains Mercury: Next, close these Vessels with the second Pot inverted: Stop the Joint most strictly with Lute, which must be applied pretty thick all round. Bury the inferior Pot in Ashes and Stones, placed thick and close round it, and heaped up to the very Joint: Put upon these Things a moderate Fire, and continue it for about half an Hour, so that the upper Pot may grow slightly red-hot. The Mercury that lies hidden in the Matrix will dissolve into Vapours, which being stopt above, will come down when again condensed: They are preserved under the Water from the too great Heat: For, this does not admit that Degree of Heat whereby the Mercury may continue in the Form of Vapours, or be resolved into Vapours when once condensed; unless there is some Air perfectly imprisoned in the Vessel, and so inclosed as not to be able to perspire: When the Vessels are grown cold, open them, and shake well the Water contained in the inferior Pot, that all the small Drops of Mercury dispersed here and there, and adhering to the Sides of the Vessel, may gather into one Mass.

The Use and Reasons of the Process.

1. Mercury intirely volatilised is obtained pure by Distillation in a moderate Fire, without any Destruction, and even without any Change, unless the digesting Fire is continued too long; provided the Distillation is performed with Discretion, and no other

other Mineral, especially Sulphur, be in the Case: For the latter may be mixt with Mercury by a bare Trituration, or even by Heat, and with it makes a black Powder called *The Æthiops Mineral*, which being agitated by a strong Fire in a high, narrow, close, glass or earthen Vessel, is sublimated, and produces that Kind of Cinnabar, which is called *faëtitious Cinnabar*; because it is quite like that native Ore of Mercury which goes by this Name (*Part I. § 402.*) As for the rest, you must use in this Distillation the same Precautions as in *Proc. XVIII.*, where a Process almost like this is described: Nay, this may even be performed with the same Apparatus, if you have it at Hand.

2. We reject here the Distillation by Ascent; because Mercury can hardly be forced up so high, without some Danger of the Vessel's being cracked: Besides, it is in this Case difficultly collected, and Part of it easily steals away, on Account of the too great Joints. It succeeds indeed better by Descent: Nevertheless, even then some Part of the Mercury either hides itself in the rough Surface of these Vessels, or penetrates through the Vessel itself: because the latter contracts Chinks pretty often, on Account of the moist aqueous Vapours that make damp the upper Vessel. Therefore, an Iron-Vessel, if you have any, is preferable: For then, when the Joints are well stoppt, you obtain the same Quantity of Mercury, as if it was expelled laterally.

3. In every Process to be made by Fire with Mercury, the mercurial Vapour is to be avoided by all Means: For breathing too much of it causes a Salivation; and breathing little and frequently of it causes Tremblings, Asthma's, Palsies, and finally Consumptions: Nay, it is also hurtful to some, if but managed with naked and chiefly sweating Hands.

P R O C E S S LIX.

The reviving of Mercury out of the sulphureous Cinnabar-Ore (Part I. § 402.)

A P P A R A T U S.

BEAT your Ore extremely fine, and mix it exactly with an equal Portion of Iron Filings, not rusty: And use the same *Apparatus* as in the foregoing Process, or in *Proc. XVIII*, but urge it with the strongest Fire that can possibly be made; the Mercury will thus be revived.

The Use and Reasons of the Process.

1. When you have a Mind to separate both these volatile Minerals, you must fix one of them: Which is done by any fixt Body absorbing Sulphur: Such as Lime, fixt Alcaline Salt of what Kind soever, *Regulus* of Antimony, and chiefly Iron: For, these must adhere to the Sulphur alone, and no way to the Mercury. Thus will you revive any Mercury charged with Sulphur, and even dissolved by Acids. It is observable in this Reviving of sulphurated Mercury by Iron-filings, that there does not come forth the Odour of Mineral Sulphur, but an unpleasant, and most singular Smell, which being condensed into an unctuous rancid Matter, darkens the Sides of the Vessels, and makes the Water turbid, into which the revived Mercury is received. But this Reviving, when accurately performed, shews that in the best Cinnabar, Mercury is above seven Times the Quantity of the Sulphur.

2. Cinnabar may be separated from Stones by Sublimation, thus: Beat it to a fine Powder, and put it into a small, narrow, glass, or earthen Cucurbite, the Belly of which, it must not fill more than one
third

third Part. Stop the Orifice at Top; this must be very narrow, to hinder the free Action of the Air: Put this small Cucurbite in an earthen-Pot above two Inches wide in Diameter, and gather Sand around this Pot, about as high as the pulverized Ore rises in the Cucurbite: Then put upon it burning Coals in such Manner that the Bottom of the Pot may be middling red-hot: Thus will your Cinnabar ascend, and form a solid ponderous Ring, which must be got out by breaking the Vessel. Observe, that if you have pure Cinnabar, whether Factitious or Native, you must separate from it the superfluous Sulphur which has not been thoroughly mixt with the Mercury: This may be done very well by putting your pulverized sulphurated Mercury into a Cucurbite, and by exposing it to a Fire not much greater than that which is requisite to sublime common Sulphur: Thus will your superfluous Sulphur ascend with a little Mercury, and form a black Crust all over the Cavity of the Vessel. For Sulphur and Mercury are much more volatile when separate, than the Cinnabar made of both. This Sublimation must also be performed suddenly with a strong Fire; nor are you to fear any Danger from it, provided you take Care that the upper-Part of the Vessel be not exposed to an excessive Heat; especially if you make Use of a small Matras: For, by that Means the narrow Orifice of it may be stoppt, and the Vessel break asunder with great Violence.

OF ANTIMONY.

PROCESS LX.

The running down of Antimony out of its Ore.

A P P A R A T U S.

1. **C**HUSE a melting Crucible, or an Earhen-pot not glazed, that may contain some common Pounds of the Ore of Antimony, broken into small Bits, of the Size of a Hasle-Nut: Bore at the Bottom of it a few small Holes, two Lines in Diameter: This may be easily done with a common Wimble, or, if this cannot do on Account of the Hardness of the Pot, with a small Wedge, which must be moved circularly with the left Hand, and mean While incessantly struck with a Hammer in the right. Let the Bottom of this Vessel be received by the Orifice of a smaller one, upon which it must be put, and when the Ore is put into it, let it be covered with a Tile; and all the Joints be stopt close with Lute.

2. Put these Vessels upon the Pavement of the Hearth, and put Stones all round them, at the Distance of six Inches: Fill this intermediate Space with Ashes, so high as that the inferior Pot be covered to the upper-Brim. Then put fresh and burning Coals upon it, and with a Pair of Hand-bellows excite the Fire, till the upper-Vessel grows red-hot: Take off the Fire a Quarter of an Hour after, and when the Vessels are grown cold, open them. You will find that the melted Antimony has run through the Holes made at the Bottom of the upper-Vessel, and makes in the inferior one a *Regulus*, from the proportion of the Weight whereof with that of the Ore, you will be able to know how much may be got out of one Centner.

The Use and Reasons of the Process.

1. The Ore of Antimony, which is always found charged with Sulphur, is extremely fusible, and when you continue too long a Fire that is somewhat too strong, a great Quantity of it is lost in the Form of Fumes: Nay, it burns very bright, on Account of the Abundance of the mineral Sulphur, and it cannot bear the saline reducing Fluxes (*Part I. § 159, &c.*) Therefore, this Kind of Apparatus is required for the running of it down, that the Action of the Air may in some Measure be stoppt, and the Antimony be in a cold Place so soon as it is melted: This is done by the Ashes wherein the inferior Vessel is immersed, which grow red-hot more difficultly than other Bodies, which bear the Fire: Wherefore, dry Baths are made with them rather than with Sand or Filings of Iron, when too great a Heat may be detrimental.

P R O C E S S L X I.

The Roasting of crude Antimony (Proc. LX.) or of its Ore, with, and without Additions.

A P P A R A T U S.

1. **C**HUSE an earthen, flat, low Dish, not glazed, and if it cannot bear being made middling red-hot, cover it over with a Coat of Lute without: Spread it thinly over with crude Antimony, or with its Ore, beaten to a pretty coarse Powder, not exceeding a few Ounces at once. Put the Dish upon a Fire-pan, having a few burning Coals in it; increase the Fire, till it begins to smok a little: Mean while, you must incessantly move the Powder with a Piece of a new Tobacco-pipe: For this causes the Sulphur to evaporate the sooner. If you increase the Fire a little too soon, the Powder immediately gathers into

large Clots, or even begins to melt. When this happens, take it immediately off the Fire before it melts entirely: Then pulverise it again, and finally make a gentle Fire under it: Your black shining Powder will assume an ash-Colour almost like that of Earth, and become more refractory in the Fire; wherefore, you may then increase the Fire till your Powder grows middling red-hot; and let it last, till it ceases to smoak.

2. If you add to your crude Antimony, or to its Ore pulverized, half or an equal Quantity of Charcoal-dust, and perform the rest as above, the Roasting will be done more conveniently: For it does not gather so easily into Clots, and melts with much greater Difficulty: When Part of the Sulphur is evaporated, add some Fat to it at several Times, as in *Proc. XXXIX. No. 3.*

Thus, you will sooner finish the Operation, and the remaining *Calx* will not be burnt to an Excess: However, take Care, not to expose it thus, to too violent and long-lasting a Fire: Otherwise a great Quantity of it evaporates. Nor does it cease intirely to smoak in a great Fire: And it will be enough if growing middling red-hot, it does no longer emit the unpleasant Smell of the Acid of Sulphur.

3. This Roasting is most speedily performed by another Method with Nitre; if, for Instance, you pound Antimony charged with Sulphur, with an equal Weight of Nitre, and throw it at several Times, and not above a few Drachms at once, into a deep earthen Vessel not glazed, and middling red-hot: A strong Detonation will be made, and the Mixture will be changed into a half-vitrified Mass, of the Colour of Liver; Take it out, grind it, and with warm Water wash off (*Part I. § 473. &c.*) the Salt that lies hidden in it. The remaining *Calx* is called *Crocus Metallorum*, or *Hepar Antimonii* (Liver of Antimony.)

The Use and Reasons of the Process.

1. No Roasting requires so great a Patience as that of Antimony loaded with Sulphur. For, the reguline Part of it is, by the mineral Sulphur, rendered the most fusible of all Metals and Semi-metals, Arsenick excepted: But, if it melts, then a further Exhalation of the Sulphur cannot be procured by continuing the Fire, otherwise than by a great Loss of the *Regulus* itself; which being not of itself very well fixt in the Fire, is the more easily carried away by the Sulphur joined to it, so that it will be entirely dissipated along with it, though it is at least above three Times the Quantity of the Sulphur. Therefore, you must roast but a small Quantity of it at once, and extend it wide, and stir it perpetually: Because, when it is too finely pulverized, or heaped up only a few Lines thick, it will not be seen to exhale any Thing, unless you stir it, though it already begins to melt at Bottom. For, the Vapours of the Sulphur passing through the Interstices of the less hot Powder which is upon them, condensate: Whereby the Powder becomes of a yellow Colour. The Roasting is done a little more easily without adding any Thing to the Ore of Antimony; especially if you prevent the Melting in the Beginning. As for the rest, this Method is hardly made use of, except when you have a Mind to make common Glass of Antimony, which is made with the already prepared *Calx* of crude Antimony. For Instance, you put this *Calx* in a strong Compact Crucible, and make your Fire gradually, leaving the Vessel open in the Beginning; that the Sulphur still remaining, may be entirely expelled: Then increase the Fire, till the Ore melts, the Vessel being covered, to keep the Charcoal from falling into it, which reduces Glass to a reguline Semi-metallick Substance. When melted, leave it so for a Quarter of an Hour, or longer, if the Vessels can bear it: Then at last, pour it out upon a flat, dry, warm Stone: It will be a Glass more or less transparent, and of a deep

yellow Colour; according as the Roasting and Melting have been performed more perfectly, and in a neater Manner.

2. *Kunkel* has made Use of another Method of roasting crude Antimony, in order to prepare a greater Quantity of the simple *Regulus* of Antimony: For, a greater Quantity of it is obtained by that Method than by any other; for, during this Roasting the mineral Sulphur carries off a small Quantity of it. But, if you urge it with a Fire too long lasting, and so strong as that it may come almost to the Degree of a reducing Fire, some Part of it is dissipated. For Instance, the *Calx* of Antimony which is of itself pretty well fixt, or the Glass of it, is disposed to a Reduction, when you urge it by a frequent Addition of a Phlogiston; now, the *Regulus* is dissipated by a Fire a little too strong; therefore, the Glass or *Calx* of Antimony is by this Method rendered volatile.

3 Nitre ground with Antimony charged with Sulphur, detonates with the sulphureous Part, and consumes it as to the Phlogiston; but the Acid of Sulphur being agitated by a strong Fire, and meeting the Nitre, the latter expels the acid Spirit of the former in a gentler Manner, and unites itself with the fixt Basis of the Nitre, and together with it constitutes a middle vitriolated Salt, perfectly like Tartar vitriolate, or like Salt Polychrest, which being washed off with warm Water, there remains the pure *Calx* of Antimony half vitrified. But if you use more Nitre, for Instance, twice or thrice as much for the Detonation, the *Calx* becomes yellow or white, and is much burnt; in the first Case it is called *Emetick*, and in the second *Diaphoretick* Antimony.

4. The Separation of Sulphur may likewise be performed by several liquid Dissolutions, and by Precipitations: For which Reason it is called by some Calcination or Roasting the moist Way. Thus, for Instance, *Aqua Regis*, and Spirit of Nitre, especially when they are concentrated, erode the reguline Substance

Substance of Antimony out of the Sulphur with a moderate Heat, and dissolve it; while they leave the Sulphur untouched: When the Solutions decanted are precipitated by a Solution of fixt alkaline Salt, andedulcorated, they produce the *Calx* of Antimony; which is nothing else but the intire *Regulus* dissolved by the Acids.

PROCESS LXII.

The Reduction of the Calx's of Antimony (Proc. LXI.) into a Semi-metallick Regulus.

A P P A R A T U S.

MIX some *Calx* of this Kind with a quarter Part of the black Flux, and put it into a Crucible; cover the Vessel with a Tile; make the Fire as quickly as the Vessels can bear it, but not greater than is necessary to melt the Flux itself: When the whole has been well in Fusion for half a Quarter of an Hour (which may be tried with a Tobacco-pipe taking off the Tile) pour it into the melting Cone, which must be warm and done over with Tallow: Then immediately strike the Cone several Times: When you have inverted the Cone, and shaken out the Matter grown cold in it, you will find at the Point a *Regulus* like (Part I. § 77), and at the Basis a saline Scoria. If you have a Mind to reduce or try a small Quantity of it, you must do it either upon a Charcoal with the cementatory or blow-Pipe (Part I. § 258); or in the Manner prescribed with regard to Tin *Proc. LII.*

The Use and Reasons of the Process.

1. The Reduction of the *Regulus* out of the *Calx* of Antimony is performed the most easily of all Metals. It is enough, if you add to the *Calx's* of Antimony only Charcoal-dust, or any Kind of Phlogiston whatever: Nor need you have Recourse to a melting *Mensstruum*, on Account of its Fusibility. But there happens

happens some Difference, between the *Calx's* prepared (*Proc. LXI.*) for, more or less *Regulus* may be reduced out of one or the other, not only with regard to the crude Antimony, but also with respect to the *Calx* you make Use of. For Instance, you will obtain, after the Reduction, above one Pound of *Regulus*, out of one Pound and an half of crude Antimony either alone, or roasted with Charcoal-dust; unless you have committed some Mistake, by making too great and too long lasting a Fire, or by using impure Antimony: For, by the first Method, you will prepare pure, unmixed *Calx* of Antimony, by the Dissipation of the mineral Sulphur and the Phlogiston; but you cannot prepare any *Calx* strictly so called by the second Method, that is, with Charcoal-dust; because, a pure Phlogiston, that is, one destitute of Acid of Sulphur, has been continually supplied, during the Dissipation of the mineral Sulphur: Therefore, in this Case, the reguline Part cannot have been burnt into a true *Calx*; but, being only separated, it had merely a false Appearance of a *Calx*: For, if you take this out of the roasting Fire in proper Time, and expose it to a melting Fire in a Vessel; it does not melt into Glass, but into a *Regulus*, not so abundant however, as if fresh reducing Powder had been added. But, it is always proper, when you are to prepare an abundant *Regulus*, or a fine Glass, to chuse that Part of the crude Antimony, which in the running down (*Proc. LX.*) got into the lower Part of the Recipient; for it is purer, more reguline, and less sulphureous; whereas that in the upper Part proves less reguline, and more sulphureous and terrestrial: On which Account it appears less compact and shining than the foregoing, and much lighter, because full of small Bubbles.

2. Before you reduce the *Calx's* made by a Detonation with Nitre, you must previously edulcorate them perfectly: Otherwise, you obtain a much lesser Quantity of *Regulus*, with regard both to the crude Antimony and to the *Calx* itself; because, when you
add

add a Phlogiston, the vitriolated Salt adhering to it, turns to Liver of Sulphur, which dissolves the *Regulus*, and in very great Part retains it joined to itself. Nor can you, however, thus obtain so much *Regulus*, as when the Calcination is made either by itself, or with only adding a Phlogiston: For during so violent a Detonation, a great Quantity is flung out of the Vessel, or vanishes away into Fumes: Besides, some Part of the reguline Substance is also washed off along with the Salt; which is very plain, when you pour wine-Vinegar upon the the Water wherewith the Edulcoration has been made: By Means of which you precipitate a red Powder, called *Sulphur Auratum*, which is composed of the Sulphur of your Antimony joined to the Semi-metallick Part. For, the Phlogiston of the crude Antimony, is not totally consumed by an equal Weight of Nitre: But, if you add twice or thrice as much Nitre; then indeed, it is totally consumed: However, a Semi-metallick Part remains so strictly united with the Salt, that it runs through the Filters. As this last part is obtained out of the warm Dissolution, in the same Manner as the *Lac Sulphuris* and the *Sulphur Auratum* are got by Precipitation; it has been but improperly called fixt Sulphur of Antimony: For it is deprived of all inflammable Matter, on which Account it is of a white Colour. It is for the same Reason, that the Sulphur called fixt Sulphur of Antimony, being melted with a very strong Fire, turns into Glass, of a much lighter Colour, and less violent in its Effects, than that which is made of *Crocus* of Antimony, because it is almost the same as Glass made with *Calx* of Antimony procured without any Addition.

3. From what has been said the Reason is plain, why simple *Regulus* of Antimony is prepared with some Loss the ordinary Way. For a Mixture of Tartar, Nitre, and crude Antimony, detonates in a strong melting Fire; but seizes upon the Nitre, which reduces the Phlogiston of the Tartar as well as the

mineral Sulphur: for this Reason the mineral Sulphur is not intirely consumed: And if it were, the Acid of it detained by the alkaline fixt Salt here produced with it, and joined with the Phlogiston of the Tartar, would nevertheless make a copious *Hepar Sulphuris*, whereby a great Deal of the *Regulus* would be retained. This appears evidently, if you add to the Scoria half its Quantity of Filings of Iron, and melt it a second Time: For then, the *Regulus* remaining in the Scoria, will subside to the Bottom of the Cone. Likewise, a great Deal of *Sulphur Auratum* is precipitated, if this Scoria is edulcorated with warm Water, and Vinegar poured upon the Dissolution. A great Quantity of reducible Flowers is also rejected during the Detonation. And as the Mixture must be put at several Times into the Fire, and must be left the longer in it, the Vessel being mean while open; a great Deal of this volatile Semi-metal is consumed, and on this Account there remains but a very small Part of the *Regulus*, at the Bottom of the melting Cone.

P R O C E S S LXIII.

The Precipitation of Regulus of Antimony, with Metals
(P. I. § 147. Coroll. 3.) *Iron is taken for an Example.*

A P P A R A T U S.

I. **P**UT one Part of Iron not rusty into a Crucible made thoroughly white-hot in a Wind Furnace. But you must chuse Bits of Iron not very thick, for Instance, small Plates, Nails, or even fresh Filings. When the Iron is perfectly white-hot, add to it, the double Quantity of crude Antimony at several Times, lest the Vessel should break asunder by the too sudden Application of a cold Body: You will see your Iron dissolved by the melted Antimony: This done, add to it at different Times, of
Nitre,

Nitre, or of any fixt alkaline Salt whatsoever, a quarter Part, with respect to the crude Antimony; leave all these Things in the Fire for a few Minutes more, that they may melt very thin together; then pour them into a melting Cone, in which, by striking it, the whole reguline Mass contained in the crude Antimony, will subside: Separate the Scoria's which will be hard: Expose them to a free and somewhat moist Air, and in a few Days they will of themselves fall into a Powder.

2. Put the *Regulus* a second Time into the Crucible, add to it one quarter Part of fresh crude Antimony, cover the Crucible with a Tile, and melt the Matter with a Fire not violently excited: When the whole is in Fusion, add at several Times one sixth Part of Nitre, or very dry fixt alkaline Salt, and a few Minutes after pour out the Mass well melted.

3. The *Regulus* may be melted a third or a fourth Time with a very little Nitre: This will detonate, and at the same Time assume a refractory Nature: If at last you use the strongest Fire, your *Regulus*, when poured out, will be finally Marked with a Star, but a great Portion of it will be consumed by the Nitre and the Fire in these last Fusions.

The Use and Reasons of the Process.

1. If you precipitate *Regulus* of Antimony, with Metals (*Part I. § 147. Coroll. 3.*) you will have the Whole of it without any Loss; but, it will be tainted by a considerable Mixture of the precipitating Metal: But, a greater Quantity of the Metal joins to it, as the Action of the Sulphur upon it is slower, and as the Sulphur itself melts more easily with the *Regulus* of Antimony. Thus, in every Precipitation by Fusion of Metals by Means of other Metals, the precipitated Body partakes of the precipitating one, except Lead alone, to which the Iron that precipitates it never mixes; because both these Metals do not dissolve each other in the Fire. The first Scoria
which

which is produced in the present Case, is Iron dissolved by the Sulphur of Antimony; for which Reason this Scoria is of a very hard Nature, and very difficult to be separated from the *Regulus*. To make it separate easily you must add an alkaline Salt, or alkaliescent Nitre, whose Acid is expelled by that of Sulphur: This Alkali dissolves the Scoria, and makes it soft and dissoluble by the Moisture of the Air. Likewise, the *Hepar Sulphuris* produced in the Operation does also efficaciously dissolve the precipitating Iron, and retains it united to itself, lest the Part of it which is dissolved by the Sulphur should again unite itself so easily to the *Regulus* of the Antimony.

2. A second Fusion is made with crude Antimony and Nitre, or with fresh alkaline Salt, to the End that the Iron remaining in the *Regulus* may be furthermore separated. For Instance, the *Regulus* which is much more refractory in the Fire than the crude Antimony, is dissolved by the Sulphur of it, and at the same Time this Sulphur meeting the Particles of the Iron contained in the *Regulus*, and having abandoned the reguline Portion of the Antimony, joins with them; when joined, making a lighter Mass, it is cast up at Top, and forms a Scoria, in which a great Deal of Antimony is adherent, for want of a precipitating Body. The Salt added over and above has the same Effect as N^o. 1. But, it is easy to conceive, that in this second Fusion, the *Regulus* is tainted with some small Quantity of Sulphur.

3. To consume this Sulphur intirely, it is necessary several Times to repeat the Fusion; which is not made so well with alkaline Salt, as with Nitre: For the latter being flung upon a *Regulus* boiling by the Violence of the Fire detonates with the Sulphur that lies hidden in it, and at the same Time becoming Alkaline by the Strength of the Fire, it assumes a refractory Nature, which is increased by a salt like Tartar vitriolate, which is produced by the Acid of the Sulphur, and the alkaline Part of the Nitre.

Nor

Nor is the pure Phlogiston, that forms the *Regulus*, free from the Force of the Nitre: Wherefore, a great Deal of the *Regulus* is calcined, and, together with the very strong alkaline Salt here produced, is changed into a Glass, which being intermixt with the Scoria's, is the Cause of their amber or saffron-Colour: This Colour is communicated to Glasses by Arsenick and the *Calx* of Antimony, unless they are burnt too long in the Fire. Those who repeat the Fusion several Times with Nitre, at last consume the *Regulus* to no Purpose, because that, which remains in the End, never becomes malleable. Nor does the Presence of mineral Sulphur at all require a frequent Repetition of the Work; for, nothing of it can be shewed in a *Regulus* once or twice purified.

OF BISMUTH.

PROCESS LXIV.

The melting Bismuth out of its Ore.

APPARATUS.

1. **B**ismuth-Ore may be melted with the same *Apparatus* used for the melting crude Antimony out of its Ore (*Proc. LX*).

2. The very same may be done in the melting Furnace, if you set it upon its Bottom with the Bed, and a Recipient outwardly applied to it (*Proc. XXXV*). In this *Apparatus*, you must break your Ore in small Bits, and mix it by *Strata* with Charcoal, or with very soft broken Pieces of Wood. But, your Bellows must be loaded with a very small Weight, that their Blast may be very gentle; nay, the Fire may even be sufficiently excited for this Fusion without Bellows, by putting only the Cover and the Funnel at Top of the Furnace: For Bismuth will not bear so great a Fire, to make its stony *Matrix* turn

turn to Scoria. The Ore being thus run down into the inward Bed, must be stirred now and then with a Poker, that the small interspersed Grains of Bismuth may be driven out, and run into the outward Bed, where they join with the rest into a *Regulus*. When the semi-Metal is melted, take away the Dross, with a Sort of wooden Scraper or Hough: And removing the Body of the Furnace, take the Ore remaining in the inward Bed, and extinguish it in a Vessel full of Water, and then wash off and reject the smallest Particles, collecting only the larger Ones, to melt them together in a gentle Fire.

3. You may also run down Bismuth in an earthen or an Iron-Vessel. Fill this with your Ore broken in small Pieces, and make a wood-Fire all round: And thus you will, by the same Method as before, easily obtain Bismuth out of a fusible Ore, especially out of a rich one.

4. You may also beat your Ore to a very fine Powder, with the black Flux, Sandiver, and common Salt, in a close Vessel like the Ore of Lead or of Tin, and melt it in a middling Fire, having a Draught of Air: But, as this semi-Metal is destructible and volatile, you must, as quick as possible, apply to it that Degree of Fire which the Flux requires to be melted, and so soon as it is well melted, the Vessel must be taken out of the Fire, and when it is grown quite cold, and broken, you will find your *Regulus*.

The Use and Reasons of the Process.

1. Bismuth is found in its *Matrix's*, either pure and in a Semi-metallick Form, or in a State of Ore, when Arsenick is joined to it: And as this semi-Metal is at the same Time most fusible; on this Account, it does not want the Assistance of any melting *Menstruum*, or of any reducing Phlogiston; but may be run down out of its Ore, by only a simple Fusion, and with a gentle Fire. If there is any small

small Quantity of Arsenick in it, the free Air and Fire dissipate it. But you can use this Fusion, only with rich and very fusible Ores.

2. If the Ore is very refractory, and the desired semi-Metal lies hidden in a small Quantity, within very narrow Interstices, then a Fire somewhat stronger is required, that, being more attenuated, it may extricate itself: But, in this Case, it will be entirely dissipated, unless you apply to it a smoaking, reducing Fire, which must be at the same Time moderate, and in some Measure confined from it. For as Bismuth is easily reduced by the Phlogiston of the Fuel of the Fire, it is also soon dissolved into Fumes and sublimed.

3. You will obtain a much greater Quantity of Bismuth, if you melt your Ore with the black Flux, Sandiver, and common Salt, in close Vessels: The Reason of this is, that the *Matrix* of Bismuth, or of its Ore, is sooner dissolved than vitrified by the Force of the Salts: Wherefore, the Particles of Bismuth being then confined, may be more perfectly precipitated; whereas, on the contrary, a great deal of it remains in the Chinks of the *Matrix*, in the foregoing Eliquations; because a *Matrix* of itself very refractory, is, by the Volatility of Bismuth, hindered from turning to Glass with Fire alone. Besides, the free Action of the Air, being excluded, and a reducing Body added, the same Quantity can never be dissipated, as when the Air and Fire act freely upon it, and a little of a reducing Body comes to your Assistance. Moreover, Arsenick is most commonly joined in no small Quantity with Bismuth: But this (as will afterwards appear in the Processes to be made with it) is reduced and precipitated, with saline reducing Fluxes, into a Semi-metallick *Regulus*, not unlike Bismuth, more fixt than Arsenick itself, sometimes volatile enough, which, nevertheless, meeting another Metal or semi-Metal, mixes with it, and is fixt.

4. The Cobalt of Arsenick (*Part I. § 325*), of almost every Kind, has something of Bismuth in it:

And as for the rest, there is most commonly no other Difference, between the Ores of Arsenick and those of Bismuth, but the greater or less Proportion of either of them mixt with the other. But, when there is but a small Quantity of Bismuth, it cannot be run down with any Profit, though Bismuth be not a Thing of the lowest Value. But, when the *Caput Mortuum* of Cobalt remaining after the Roasting of it, is melted with Flints and Pot-Ash, to make with it the Glass called Smalt; a *Regulus* is produced much like Bismuth, though different from it in some Measure. See *Part I. § 407. Schol.*

OF ZINK.

PROCESS LXV.

Zink (Part I. § 14.) is sublimed into irreducible Flowers.

APPARATUS.

1. **I**F you put a few Ounces of Zink into a Pot, or a small earthen Cucurbite, and place this Vessel horizontally, or rather with its Orifice upwards, in a reverberatory Furnace, fitted for Distillations of Oil of Vitriol, or others requiring the strongest Fire, and fit to it, by means of an Aludel, a large glass-Recipient, in such Manner, that you may look within through its transparent Bottom, into the Cavity of the small earthen Cucurbite; after having carried your Fire to a very great Degree of Brightness, you will see your melted Zink suddenly take a Flame of a green Colour, and at the same Time a very thick grey coloured Smoak arise, which will be pushed forward into the Recipient, like Cobb-webbs fluttering in the Air, and cover the whole Inside of it, and a little after hinder you almost entirely from seeing any further. After you have continued your Fire for an Hour or two; let the Vessels grow cold,

and

and when you open them, a very thin Fume of the garlick-like Smell of Arsenick, will break forth, and vanish very soon after. The Recipient will be covered over on the Inside, with a Coat of very soft, impalpable, and light Flowers of a bluish white Colour: But, the Aludel will be incrustated, partly with the more ponderous blue Flowers, consisting of coarser Grains, and partly with the solid Sublimate produced from the small Drops of melted Zink entirely sublimed, the grey Flowers of the destroyed Zink being every where interposed. You will find in the earthen Vessel itself something still of the Zink covered and sheltered as it were with a Blister, from being entirely burnt, or sublimed: Which is the Flowers burnt, and almost half vitrified. If you use a Fire so gentle, as that the Zink may not take Flame; hardly any Thing will evaporate in Form of Zink, or of Flowers.

2. If you expose to a middling Fire, having a Draught of Air, two or three Ounces of Zink, in an open earthen Cucurbite, upon a stone Support, as one places a Crucible; Zink takes Flame much sooner than in a close Vessel, and fills the whole Cavity of the Vessel with very white Flowers like Locks of Wool: But, so soon as the Vessel is full with these Flowers, so as that you can no longer see the Surface of the Zink; the Flame, which was very bright before, gradually diminishes, till it at last ceases entirely; so that the Zink can no more be brought to a Dessagration, not only with the same, but also with a stronger Fire. If then you take away the Flowers with a small Iron Ladle, and free the Surface of the melted Zink at the Bottom of the Vessel, from those which covered it; a bright Flame is again produced as before, and in a few Minutes the Cavity of the Vessel is filled with Flowers of the same Kind: If you continue this Work in the same Manner; at last all your Zink, provided it was pure, is resolved into a great Quantity of very white Flowers; nor does a great deal of it fly away, unless the Fire acts too

violently. But the Flowers apply themselves presently to the Sides of the Vessel, and even adhere to the Surface of the Zink itself; nor can they afterwards be further changed, or rendered volatile, by the same Degree of Fire by which the Zink has been burnt and sublimed; so that by this Method you may prepare Abundance of Flowers of Zink in the most convenient and neatest Way. Nevertheless, you may also adapt Aludels, or only cylindrical Segments, to the Orifice of your Vessel: By which Means you will obtain a little more abundant and more subtile Flowers. But, that the Surface of your Zink may be now and then freed from the Flowers that cover it, and the whole Cavity of the inferior Vessel be rendered free, it is proper to make a Hole at the Side of it, so large as that you may take out through it the Sublimate, with a small Ladle, as was said before.

3. When you apply suddenly to pure Zink the strongest Fire with a Draught of Air; the whole of it vanishes: Nor is it confined by the Crucibles being stoppt with Lute. For Instance, if you put an Ounce of pure Zink into a small Crucible covered with a smaller inverted one, stopping all the Joints well with common Lute, and put it into a wind-Furnace, surrounding the whole Vessel with Charcoal and burning Coals, and excite the Fire to its utmost Degree, by applying the Bellows to the bottom-part of the Furnace, and continue it for half an Hour, when afterwards you take out the Vessel, you will not perceive therein the least Foot-steps of Zink, or of the Flowers of it. The very same Thing happens with the other Semi-metals, though not so quickly.

4. If you mix the white Flowers of Zink, or the blue and grey ones calcined to a white Colour in a middling open Fire, with common reducing Fluxes, such as are the black Flux, and the white (*Part I. § 162. &c.*) adding fluxing Salts to them, they cannot afterwards by any Means be reduced in the
same

same Manner as the other Metals and Semi-metals, by being exposed to a melting Fire. Nor has any Method hitherto been invented, or communicated at least by the Inventor, whereby the Flowers of Zink may be reduced to a Semi-metallick State: Since they rather are fixt so far in the Fire, as to be vitrified with Fluxes.

5. When the grey and blue Flowers are melted with some very fusible Salt, though this be impregnated with none or at least very little Phlogiston, you may obtain out of them, I shall not say, reduce from them, a few Grains of Zink. For Instance, if you mix by Trituration the Flowers just mentioned, with Sandiver, or the caustick alkaline Salt * which is prepared out of the inspissated Lye of Pot-ashes and Quick-lime, and expose them in a Crucible, to a Fire not greater than is necessary to melt the Salt well, and then take them presently out of the Fire, and sling the Crucible with the Salt grown cold into a clean Bason full of warm Water, you will find, after having washed off the Salt and the lightest Dross, a few and very small Grains of Zink, most commonly covered with yellow Crusts, precipitated here and there at the Bottom of the Vessel, and not to be collected without a tedious Labour. These Grains of Zink, if not pretty large, hardly melt into a *Regulus*, but perish intirely, being resolved by the Fire into small Flames and Flowers. But, you must not for this Purpose use the black or the white Flux, because they require so great a Fire to be melted, that the small and widely-dispersed Particles of the Zink are burnt much sooner than they can be precipitated by the concomitant Matters melted sufficiently thin: Which is very plain from the small coloured Flames and Flowers that break forth. Nor does the above-mentioned very acrid Salt bear the Addition of the Phlogiston; nay, when already

* The caustick Alkaline Salt here mentioned to be made of Soap Lees and Lime, is commonly known by the name of *Lapis Infernalis*, the Caustick so generally used by Surgeons.

melted, if you add the least Fat to it, it immediately grows solid, and requires a Fire equally strong as the black Flux does, to be brought again to a State of Fusion: And this seems to be the Cause why Grains of Zink so difficultly run into one reguline Mass; because this Salt, while it absorbs the Phlogiston where-with Zink is full, forms those small yellow Crusts round the Grains of the Zink, which Crusts are difficult to be melted.

The Use and Reasons of the Process.

1. The Reason is plain from this singular Property of Zink, why we try in vain, by Precipitation by Fusion, with the Assistance of saline, oily, reducing Fluxes, to produce Zink from its Ores hitherto known in *Europe*, in the same Manner as we commonly use for other Metals and Semi-metals. It is as plain, why it can much less be collected in the Beds of the Furnaces (*Proc. XXXIV*), by a Stratification with Charcoal, by Means of the Vitrification of the terrestrial Bodies adherent to it, and of a violent Fusion, excited with the Blast of Bellows; but ought rather to be collected and sublimed (*Part I. § 409. &c.*) in Places pretty cold, and not much exposed to the Action of the Wind.

2. Mean while, the Zink that lies hidden in Ores, or other compound facitious Bodies, betrays its Presence by the Flowers which it emits from itself when urged by a strong Fire, and by the golden citron-Colour it gives to Copper. For both these Effects were never produced by any other known Body, as much as can be collected from all Experiments: Wherefore, we may as surely conclude the Presence of Zink from them, as we surely conclude that of Iron from the Action of the Magnet.

3. A strong open Fire, and sublimatory Apparatus (*Part I. § 462*), are required to collect these Flowers: However, you must with great Care avoid the too-violent Passage of the Air through the Furnace, and the least Blast of it through the sublimatory

tory Pots : For the softest and lightest Flowers are dissipated by the least Motion of the Air. Therefore, it is proper to use large Aludels : By this Method you will obtain Abundance of Flowers out of Calamine, especially if you break it into small Bits of the Size of a Pea, and lay it in *Strata* with Charcoal ; when those are consumed, you collect it out of the Ash-hole, and put it in again with fresh Charcoal. Thus it is sometimes for a very great Part resolved into Fumes and Flowers, according to its different Degrees of Purity. These Flowers first come forth bluish, then more and more grey, and white at last. They are vastly like the Flowers produced out of Zink itself and called *Nihil album*, *Nihil gryseum*, according to the Difference of the Colour, which nevertheless depends on the Impurities mixt with them, or (if the Operation has been neatly performed) on very small Portions of Zink, not yet destroyed, or from both Causes. For, Zink may indeed be collected out of them, according to *Appar.* N°. 3. and if they are again made red-hot for a few Minutes, they grow perfectly white ; because Zink is not very constant in the Fire. They are also called *Pompholyx* : And we shall leave to others the Care of finding out, whether it is the same as the *Pompholyx* of the Ancients, and whether the *Spodium* of the Greeks finds also its Place here : But, whoever has a Mind to sift these Matters, let him not undertake it without having Recourse to Experiments ; lest he should afterwards give us Words for Things ; nor pretend to reconcile the various Opinions of all the Authors, many of whom have stuck to Words much more than to Things.

4. *Pompholyx* and *Nihilum* (*Nil*) are indeed sold in Shops, but seldom genuine : For, as they are collected in small Quantity, they are adulterated in a thousand different Manners : While the several Kinds of light white Marls, the Parget made of burnt Spaad, and the white, fat, Boly Earths, such as the Fullers-earth, the Hessian-earth, &c. or even

compound Masses, made several Ways with these, both by Nature and Art, are sold for the white *Nil* of the Shops: See *Henckelli Pyritolog.* p. 581. Which Fraud is not always easily detected: Nevertheless, it is often known from too great a specifick Gravity, from an excessive Roughness, and from the Want of a quick Dissolution in Acids. But, it is better for him who wants to have true genuine *Nil*, to prepare it himself.

P R O C E S S LXVI.

The Cementation and Fusion of Copper with Zink-Ore.

A P P A R A T U S.

TAKE of Zink-Ore, for Instance, of Calamine reduced to Powder, *one Part and a half*, and as much of comminuted Charcoal; grind them together, and moisten them slightly with Water: Fill any melting Vessel with this Mixture, put between and at Top Plates of the purest Copper *one part*, and again cover them with Charcoal-dust, and put the Whole in a wind-Furnace, covering it with a great Quantity of Charcoal; light them by slow Degrees, and then increase the Fire, to make the Vessel grow white-hot: When you see a Flame tinged with a grey, bluish, or purple Colour; try here and there with a strong Iron-Wire, whether the Copper is melted under the Charcoal-dust: Which is done with a much lesser Fire, than Copper alone requires for the Fusion of it: Then moderate your Fire, that it may not be too violent: Finally, having continued the Fusion a little longer, let the Vessel be taken out of the Fire, that it may cool of itself, or let the melted Mass it contains, if considerable, be poured out into a dry and middling-warm Vessel: You will find, when you break the Copper, that it is tinged with a golden Colour, and that the Weight of it is increased a considerable Quantity, which is sometimes one quarter or one third Part of the

the Weight of the Copper made use of, its Malleability remaining perfect in the Cold: But the more it grows hot in the Fire, the more brittle it becomes; so that, when it grows middling red-hot, you will easily break it into small Bits with a wooden Mallet, or if it is handled roughly, having then lost all its Tenacity.

2. If Calamine, or any other Body containing Zink, and to be tried by this Method, is full of a great Quantity of Lead, or of some other Metal not separable from it; it is proper, that the Mixture of it with pulverized Charcoal made as before (N^o. 1), be ground very fine, that some Lute be mixt with it, and that it be strongly compacted and crammed into a melting Vessel, to the End that, the Plates of Copper put at Top being melted, they may not get to the Bottom: Then, you must put a good Quantity of Charcoal-dust upon your Plates of Copper, and do the rest as before: Likewise, melt the Copper in a Fire much gentler than when it is alone, and it will be tinged, though with a Colour somewhat paler, nor will the Weight of it be so much increased.

The Use and Reasons of the Process.

1. In this Process the Copper is penetrated by the Zink, in form of a Vapour, and the Zink is fixt in it: Which plainly appears, because when you stop the Passage of the Copper, by putting Lute between, to keep it from running down into the Mixture at the Bottom of the Vessel, nevertheless its Consistence, Colour, and Constitution change in the Fire, and its Weight increases, insomuch that it is certain the sublimed Mater has produced these Effects. The Charcoal-dust does also prevent the burning of the Copper, and hinders the Zink received by it from being again burnt and dissipated. For, if you melt tinged Copper in a Crucible, without any Addition, it takes a bright Flame almost like Zink itself, and spreads Abundance of white Flowers tinged here and there with a Citron-colour, which seems to
 proceed

proceed from the Copper carried away along with them, being otherwise like the Flowers produced (*Proc. LXV*): But, in this Case, a great Part of the Weight of the Copper is lost at the same Time, and the Colour of it grows every instant worse and worse. For this Reason, when you tinge Copper with Calamine, to get Profit by it, you must try by Experiments, what Degree of Fire you are to use, and in what Time the Copper acquires the greatest Weight, and assumes the finest Colour: For, it is plain to the Eye, that a great deal of it also vanishes in Form of a thick Fume. However, it is observable, that Brass or Copper impregnated with Zink, being made middling red-hot in the Fire, is not so easily calcined as pure Copper. There are also a great many Differences in the Calamine: For, a Quantity of some Calamine increases the Weight of Copper, more than the same Quantity of some other does. The Beauty and Malleability of the tinged Metal are likewise different: For, some Calamine affords a great Deal of Lead and Iron; whereby the Copper is spoiled and rendered pale and brittle; though the Weight of it is very much increased at the same Time. There are even some Species of this Stone, that require a previous Roasting, whereby a great Part of it must be dissipated, before it is rendered fit for this Use; while others may be immediately made Use of.

2. There are, besides the Calamine, many compound artificial Bodies, which likewise tinge Copper with a yellow Colour, and increase the Weight of it: Such as are the *Cadmiae Fornacum*, or Tutty (*Part I. § 89*); but, all Kinds of Tutty are not so, but those only which proceed from Zink-Ores, or from compound Metals in which Zink enters: Of which all that has been said of the Calamine is equally true. A most elegant and pure Kind of it, is the Tutty used in the Apothecaries Shops: It is very ponderous and solid, resembling cylindrical Segments by its Figure, rendered convex and hollow by the Obstacle to which the Vapours have applied themselves, granulated on the

the Outside, of a bluish Colour, smooth within, and yellow. Nor is it dubious, that there are several native Minerals, or several Kinds of Tutty produced from them, that would have the same Effect: But, it is highly probable, that their Nature is hitherto unknown to us, because the Examination of them has been neglected to this Day.

3. Copper tinged in this Manner, when it preserves its Malleability, is called *Brass* or *yellow Copper*; and as it is, by its Beauty, easy Tractability, and long Duration, very fit to make Utensils, and the metallick Mass is so easily increased in the making of it; on this Account, a very great Quantity of it is made in several Places, when the necessary Ingredients may be conveniently prepared.

4. The Flowers, which are collected during the making of Brass, or the melting of it a second Time, and the roasting of the Calamine, as also the Flowers of Zink itself not yet intirely burnt; likewise, all the Sublimates proceeding from Bodies of the same Nature, being cemented in the same Manner as the Calamine, that is, with Charcoal-duft and Plates of Copper, and melted, make Brass of the best Kind. But, the same being burnt in a slow Fire, are so fixt, that in close Vessels, and a strong Fire with a Draught of Air, they turn to a yellowish Glass; as is well observed by *Henckel* concerning Zink; however, he would, it seems, have this understood only of the Flowers of it: See *Proc. LXV. Appar. N°. 4.*

5. It is a wonderful Thing, that Zink itself being plainly melted with Copper, robs it of all its Malleability: As may be experienced in the making of Prince's-metal (*Part I. § 88*): While being at the same Time applied by way of Vapour, and lying hidden in the Calamine, in the Sublimates, and in the Flowers, it does not take away the Malleability. If this does not proceed from the Concurrence of Lead, according to the Opinion of the Author just quoted, or from a very intimate Junction of the Zink and Copper, the Reason of it is still a perfect Secret

Secret. Nor is the Reason yet sufficiently evidenced, why a great Quantity of excellent Calamine requires a previous Roasting, before it can be used for the making of Brass; unless you have a Mind to render this Metal less fine and malleable. Which *Phænomenon*, as well as a great many others falling under the Hands of one busied that way, are well worthy of being inquired into.

OF MINERAL SULPHUR.

PROCESS LXVII.

The Distillation of Sulphur out of the Pyrites, and other sulphureous Minerals.

A P P A R A T U S.

BEAT the yellow Pyrites, or any other sulphureous Mineral, to a coarse Powder, put it into an earthen Retort, or into a glass-one coated with Lute, having a long large Neck, and perform the Distillation in the same Manner as (*Proc. LVIII.*) was prescribed about Mercury. But, you are to observe, that, if this Mineral is so refractory in the Fire that it does not grow soft when made middling red-hot, you may make an Experiment with a greater Quantity of it exceeding two or three Pounds, and increase the Fire more quickly, and thus perform the Operation in a shorter Time. Of this Kind is the yellow martial Pyrites, which is chiefly the Ore out of which almost all the common mineral Sulphur is got (*Part I. § 316, 347*). But, if it grows soft when it begins to be red-hot, and the Ore is inclined to melt, you must put a smaller Quantity of it into the Retort, and manage the Fire more gently, whence the Distillation lasts a longer Time: This the Pyrites of Copper, or the yellow Copper-Ores (*Part I. § 369*) do require, as well as the common Lead-Ores;

Ores; for so soon as they melt, the Exhalation of the Sulphur is in close Vessels almost intirely stopt. Nevertheless, this Inconvenience may be remedied in some Measure, by interposing some refractory Body, that exhales no Sulphur in the Fire, though it must not absorb or corrupt the Sulphur itself; such is pure Sand washed clean, and of the Nature of the Stone called *Quartz*. But you must avoid all Stones of the lime, chalk, or spaad-Kind.

2. When the Retort has been middling red-hot for an Hour or more, let the Vessels grow cold: All the Sulphur cooled by the Water will adhere to the Extremity of the Neck of the Retort, from which it must be melted off, by a gentle Heat that does not kindle Sulphur; or you may take it out by breaking or cutting off the Neck; then weigh it.

The Use and Reasons of the Process.

1. As there are in Minerals many volatile Matters besides Sulphur; it is easy to conceive, that it is not always got pure out of them, but often joined with other volatile Substances, that taint it; which may be judged with some Probability, from its Colour: For pure sublimed Sulphur is always of a fine Yellow somewhat deeper than the Citron-colour; but, its being of a red Dye shews that Arsenick has been sublimed along with it: But, though Mercury, when sublimed with Sulphur, does likewise give it a reddish Colour, it seldom mixes with it. However, if this should be the Case, you may easily distinguish it from the striated Figure of the broken Sublimate, from its great Weight, and from the Place to which it has applied itself during the Sublimation; for, where Cinnabar applies itself, there can remain no Sulphur, nor any Arsenick.

2. By this Distillation, a most considerable Quantity of Sulphur may be got out of the Pyrites: but there remains a very small Quantity of the metallick Earth

Earth of Copper and Iron joined together, which must at last be separated by Means of a very strong, open, long-lasting Fire, and by other Remedies already mentioned in the Processes about these Metals.

3. If you want the Apparatus necessary for this Process, or care not to give yourself so much Trouble; you may have Recourse to a plain Roasting; and put, for Instance, one docimaistical Centner into a Test covered with another Test inverted, and roast it under the Muffle of the docimaistical Furnace, or in a gentle open Fire slowly applied, like an Ore to be prepared for Fusion: In which you are to take care, that the remaining *Calx* be not brought to a Fusion, or rendered clammy, by a greater Heat than it can bear: This done, if it ceases to spread an unpleasant sulphureous Smell; let it grow cold, and weigh it, to know how short it falls of one Centner: Which Deficiency will be the Quantity of Sulphur that was in the Ore. But, it is proper that you should know, either from the outward Appearance, or from the Smell which your Ore emits, that it is indeed sulphur Ore, or that Sulphur is at least prevailing in it; because all volatile Substances occasion a Diminution in the Weight of Ores, by roasting: Nor will you be as sure of the Purity of your Sulphur, and of Course of the Quantity of it when rectified, as if you had collected the volatile Part itself.

4. You may know bituminous Minerals (*Part I. § 318. &c.*) from the Flame which they take in the Fire, from a thick sooty Smoak, which mineral Sulphur never emits, and from their offensive or pleasant Smell: They may also be tried with greater Exactness, by Distillation out of a Retort, in several Degrees of Fire.

PROCESS LXVIII.

The rectifying and subliming crude Sulphur into Flowers.

APPARATUS.

PUT your Sulphur again into a Retort, having a wide-open Neck cut off shorter; that it may not be easily stoppt, nor the Extremity of it reach the Water in the Recipient: Let the Joints be strictly closed with Lute, and, with the same *Apparatus* as in the foregoing Process, repeat the Distillation, which may also be very well made in the Sand-bath. But, you must use a Fire much gentler than in *Proc. LXVII*; nor must the Vessel be red-hot in the End; but you must continue the same Degree of Fire, by which the upper-Part of the Recipient which is void of Water is darkened, and the Sulphur begins to distil from the Neck of the Retort; because Sulphur, once expelled out of its *Matrix* by a strong Fire, when alone, cannot bear the heating red-hot of the Vessel: The Sulphur will distil pure; because it has deposited at the Bottom of the Retort, what it had brought along with it the first Time, from the fixt Part of the Ore which is metallick, and from the Arsenick (unless it is urged by too violent a Fire) because a Residue more fixt than Sulphur remains, which fixes itself more strongly with fixt Bodies. This Residue is called Scoria of Sulphur, in German *Schwefel-Schlacke*, or Dross of Sulphur.

2. If you will have very pure Flower of Sulphur, put Sulphur into a wide Cucurbite, or an Iron-Pot; put upon this an Alembeck, or another Vessel inverted and very large, and stop the Joints with Lute: Then, bury the inferior Vessel that contains the Sulphur so deep in a Sand-bath, that the Sand may be about as high as the melted Sulphur; or

put

put small burning Coals round the Vessel, as it stands upon the Pavement of the Hearth. Let the Heat you apply be not greater than what is required to melt the Sulphur; and continue it such for several Hours, that is, according as the Quantity of Sulphur is great, and the Vessel wide: All which Things must be determined from Experience. You may also try whether the Sulphur is melted, and how much of it remains; by boring a small Hole in the Top of the Alembick, or in the Bottom of the upper-Vessel, not exceeding the Size of a Pea, through which you may introduce an Iron-Wire, to the very Bottom of the Vessel that contains the Sulphur. However, take as much Care as possibly you can, not to blow any Air in with your Mouth, through the Tobacco-pipe, if you make this Trial with one: For, if the Fire is a little too strong, the Surface of the melted Sulphur immediately takes Flame, and by this Means the Vapours of it moving upwards, break the Vessels asunder with great Noise, and with some Danger to those that stand by. If the greatest Part of the Sulphur is sublimed, remove the Fire, and when the Vessels are cooled a little and then opened, you will find in the upper-one, and in the Brink of the inferior, light, soft Flowers of Sulphur, of a fine yellow Colour, having the Characteristicks of perfect mineral Sulphur, and made perfectly pure by Sublimation. There remains at the Bottom the impure Sulphur, which must be taken out of the Pot still warm; because it adheres strongly to it, when grown cold.

The Use and Reasons of the Process.

1. Sulphur, when it is for the first Time expelled out of the pyritose Ore, being agitated by a strong Fire, carries some Copper and Iron away with it: But, a greater Quantity of these Metals distil along with the Sulphur, as the Ore is more arsenical; because Arsenick is more rapacious than Sulphur, and
 passes

passes with the Sulphur, chiefly in the End of the Distillation, when a stronger Fire is used. This appears plainly, when you urge with a strong Fire the Residue which remains in the Retort after the rectification; for then a transparent red Arsenick, and a red and yellow Arsenick, are sublimed and come over. The *Caput Mortuum* which then remains, being roasted in a close Crucible, in a violent Fire, is in great Part attracted by the Load-stone applied to it, and when you extract a Quantity of it somewhat greater, it may with the white Flux, Glass, Sandiver, or Borax, be reduced into a *Regulus* of Iron (*Proc. LIV.*) but brittle, and still containing a little Sulphur. The Copper betrays itself, when you roast gently the *Caput Mortuum*, then expose it to the Air for some Days, and then extract it with Water: For Calx of Copper may sometimes be precipitated out of this Water, by putting in it Plates of pure Steel, which Calx must likewise be reduced to a *Regulus* (*Proc. XXXVIII.*) As then this is done in close Vessels, and in a slow Fire gradually increased, it is self-evident, that the same succeeds still much better in an open, strong Fire, suddenly applied, such as is used by Assayers in the roasting of sulphureous, pyritose, arsenical Copper-Ores, of which we have spoken (*Proc. XXXIX.*) But there does not remain an equally great Portion of *Caput Mortuum* from all Sulphur: But if Sulphur is expelled out of a small Quantity of Ore that has once undergone a slow gentle Fire in a Retort; a very small Portion of it is gotten: You obtain more of it, when a greater Quantity of Sulphur is expelled hastily.

2. It has been imagined that there were several different Species of Sulphur, from the several Mixtures of these heterogeneous Matters: For all pure Sulphur is ever one and the same. For Instance, the golden coloured Sulphur both transparent and opaque, the red Sulphur, the orange-coloured one, the ruby coloured Sulphur, and the ruby coloured Arsenick, are nothing but Sulphur and Arsenick.

mixt in different Proportions, and called by different Names. Likewise, the white, grey, and ash Colours, &c. of Sulphur, depend upon the various Mixtures of Earths, partly metallick and partly un-metallick, with the same: Its very Consistence is on the same Account changed to such a Degree, that you can hardly judge from its outward Appearance, that it is for the greatest Part Sulphur. This may be seen in the Sulphur, which, during the Roasting of pyritose Ores made in a half suffocated Fire, runs sometimes between the Bits of the Ore, and being collected when grown cold, is called in German *Tropf-schwefel*. *Sulphur vive*, or native Sulphur, is likewise found under various Forms. But you will easily find out by a gentle rectifying, what Body is mixt with the Sulphur in any Case whatever.

3. Whenever you rectify and sublime Sulphur, it does not always suffer an essential Change; but remains uncorrupted in a close Fire: But, when oily, fat, alkaline, and such like Matters are joined to it, the Texture of it is destroyed. The combined Actions of too free an Air and of the Fire, destroy it: Besides, in an open Fire, the inflammable Part of it takes Fire, and is consumed. Wherefore the acid saline Part being a second Time disengaged is by the burning Phlogiston resolved into a most suffocating Fume, and again is very greedy of Water, which it intirely rejected in its Conjunction with the Phlogiston. Whence, this Acid may then be also very well collected by Means of Water or of its Vapour, not being intirely disposed of itself to gather into large Drops, and apply itself to the Sides of the Vessels. This acid Fume of inflamed Sulphur, is commonly collected, by putting a Bell or a large Alembick over it, and is called *Spiritus Sulphuris per Campanam*, Spirit or Oil of Sulphur by the Bell. But it is most conveniently collected by the following *Apparatus*. Take a Cucurbite, as large as you can find it, not yet cut off at Top, and with a hard, cutting, sharp Flint, mark in the Belly of it a square, oblong

oblong Figure, four Inches broad, and three Inches high, dextrously applying to it the acute Angle of the Stone in such Manner, that it may in all its Tract engrave a deep Furrow in the Glass: This done, touch every Point of the said Furrow, with a strong red-hot Iron Wire: By this Means, you will cut off from the Cucurbite, a Piece of Glass like the circumscribed Figure. Put this Cucurbite under a Chimney that carries Smoke well, and in such a Situation, that the Hole may be forwards, and the Cucurbite inclined backwards a small Matter, and pour into it one or a few Ounces of warm Water: Then introduce a small shallow wide China-Vessel full of pure Sulphur, through the Aperture made in the Belly of the Cucurbite, and set this Sulphur on Fire with a Thread dipt in Brimstone: When the whole Surface of it is on Fire; put a Plate of Lead against this Hole, that it may not admit more Air than is necessary to maintain the Flame. The acid Spirit of Sulphur will apply itself to the Side of the Cucurbite, made moist by the warm Water, and, running again to the Bottom, it will mix with the Water, which being kept warm by the Contact of the Vessel in which the Sulphur burns, and spreading Vapours, disposes to a Condensation the acid Spirits that are expelled. But the Sulphur that is burning in a free Air, commonly contracts, at length, a small Crust arising from the heterogeneous fixt Matters, somewhat hard, which hinders the Flame from further consuming the Sulphur: Therefore this Crust must be removed about every Quarter of an Hour, if the Sulphur is not perfectly pure: Which done the Flame is again revived. Nay, it is also extinguished by the Acid, which the half suffocated weak Flame of the Sulphur has not been able to dissipate, there remaining in the Surface of the Sulphur grown cold small Drops of a very acid Nature. If you find that this is the Case, you must immediately add fresh Sulphur, and admit a greater Quantity of Air: Otherwise the Flame once extinguished, is

very difficultly lighted again. You put in fresh Sulphur with a small Iron-Ladle, with which you must also remove the Filthiness that has successively gathered and been introduced along with the Sulphur. Do the same constantly for one or several Days, till you have gathered the desired Quantity of Spirit. It will be as strong as if it had been collected without Water, and even in greater Quantity. What Methods and Operations soever you may use for the collecting of Spirit of Sulphur, you will never hinder the greatest Part of it from evaporating, unless you will have it diluted in a great Quantity of Phlegm, or fixt in some alkaline Body or other, from which you will hardly separate it with any Profit.

4. You may very well find out with a fixt Alkali, the Proportion in which the Acid and the Phlogiston are combined in mineral Sulphur; and separate them with the same fixt Alkali, in the following Manner. Take of very pure Flowers of Sulphur, one Part, of very dry pot-Ash beaten to a very fine Powder in a warm Iron-Mortar, two Parts: mix them; fill a Crucible with this Mixture, cover it with a Tile, and put it into a Fire of a middling Strength. The Mixture will soon melt; pour it next into a dry Iron-Mortar, and with all possible Care scrape off what adheres to the Vessel; then beat the whole to a Powder: Divide this into two equal Parts in a Pair of Scales: Roast one Part of it in a clean earthen flat Vessel, not glazed, first with a gentle Fire, which must be increased more and more, till the Vessel grows middling red-hot; stir it now and then with a Tobacco-pipe, taking great Care mean while, that no Ashes fall into it; lest the Weight should be falsely increased: If the Salt grows quite white, and no longer emits any Smell, it is a Sign that the Phlogiston is dissipated: The acid of the Sulphur will adhere to the remaining fixt Salt, with one Part whereof it has turned to a Tartar vitriolate, out of which it cannot be expelled by Fire alone. Weigh the

remaining Salt. Dissolve the other Portion of this Liver of Sulphur in a glass Vessel, with treble the Quantity of pure Water: There will remain a brown Sediment, which will be Sulphur not quite dissolved by the Alkali: Pour upon this Solution the strongest Spirit of Vinegar drop by drop, a white Powder will be precipitated, which is called *Lac Sulphuris*, or Milk of Sulphur: Stir up this Liquor, and pour it quite turbid into a filtrating Paper; when it is all gone through, pour again upon it Spirit of Vinegar drop by drop, that in Case more of the *Lac Sulphuris* is again expelled, it may be joined to the foregoing, by repeating the Filtration: What gathers in the filtrating Paper being dry, if you distil it out of the Retort, it will afford Sulphur (*Proc. LXVII.*) Thence it appears, how much Sulphur was hidden in the first Portion before the Roasting. But as the Acid of the Sulphur remained alone in the first Portion, after the inflammable Part was dissipated, it is certain that the Excess of the Weight of the extracted Salt, by which this surpasses the Half of the Weight of the Alkaline Salt employed, proceeds from thence, and this Excess of Weight shews of Course, how much Acid there is in the Sulphur which you have got by Precipitation and Sublimation. Thus you find that the Acid is about fifteen Times more weighty than the Phlogiston, as has been demonstrated by Dr. Stahl. But, as during the Fusion of the Liver of Sulphur, not only Part of the pure Sulphur is dissipated, but there is also an unpleasant Smell perceived, which is different from the Odour of Sulphur, such as is emitted in the subsequent Roasting of the Liver of Sulphur; we are hereby informed, that Part of the Phlogiston having left its Acid, is at that Time dissipated, and that on this Account more Acid is attributed to the remaining Sulphur expelled with Vinegar and purified by Sublimation, than it has in reality. Therefore, it is proper, that you should use pot-Ash made perfectly pure, and try the *Caput Mortuum* remaining after the Sublimation of the *Lac Sulphuris*,

Sulphuris, whether and how much Tartar vitriolate it contains; which is found out by Edulcoration with warm Water, and by the Diminution thus made in the Weight of the dried Residue; because the Tartar vitriolate being already produced in the Liver of Sulphur, would remain with the *Lac Sulphuris*, in the filtrating Paper, as a Salt very difficult to be dissolved: Therefore, as much Acid as is adherent to such a Weight of Tartar vitriolate, so much are you to subtract from the Increase of the Weight.

5. Mineral Sulphur may be produced by Art several Ways, out of any Acid and Phlogiston whatever. This is most conveniently performed by *Stahl's* Method, as follows: Mix with Tartar vitriolate, in order to facilitate the Melting of the refractory Salt, an equal Weight of Pot-ash, to which you must slightly mix one eighth Part of soft pulverized Charcoal. Put this Mixture at several Times into a red-hot Crucible, which must be covered with a Tile, lest a great Quantity of the Phlogiston should be dissipated by the Fire. The Mixture will melt, and Liver of Sulphur, all the Principles of which are present, will soon be produced: When this is dissolved in Water, *Lac Sulphuris* may next be precipitated out of it, and this be sublimed into perfect Flowers of Sulphur *.

* Sulphur may be produced of animal Urine, and *Stercus*, according to the most ingenious and skilful Chemist Mr. *Ambrose Godfrey* [*Hanckewitz*] F. R. S. in his Account of his Preparation of the Phosphorus, wherein he has succeeded beyond all, who have attempted that most curious and surprizing, though dangerous Process. See the *Philos. Transact.* N^o. 428. p. 70.

OF ARSENICK.

PROCESS LXIX.

The Separation of Arsenick out of its Ore, by Sublimation.

APPARATUS.

1. **D**O every Thing as was said about Sulphur and Mercury: But let the Vessel which is put into the Fire with the Ore in it, be of Earth or of Stone, and the Recipient be of Glass, and of a middling Capacity: Nor is it necessary that this should be filled with Water, so it be but well luted. The Fire must likewise be stronger, and continued longer, than for the extracting of Sulphur. Nevertheless, every Kind of Arsenick cannot be extracted in a confined Fire: For, it adheres to the *Matrix* more strongly than Sulphur and Mercury. You will find in the Part of the Vessel which is more remote from the Fire, pulverulent and subtile Flowers of Arsenick, but there will adhere to the posterior Part of the Neck of the Retort, small solid Masses, shining like small Crystals, transparent, sometimes gathered into a solid Sublimate, and perfectly white, if the Ore of the Arsenick was perfectly pure: Which nevertheless happens very seldom. The Flowers are most commonly thin, and of a grey Colour; which proceeds from the Phlogiston mixt with the Mass; they are often of a citron or a golden Colour; which is a Sign that there is in the Mixture some of that mineral Sulphur, which commonly proceeds from the white Pyrites, with which something of the yellow sulphureous Pyrites is almost always intermixt. But it will be a Sign of a considerable Mixture of Sulphur, if you see the red or yellow melted Sublimate, of which we have already spoken (*Proc. LXVII*). Wipe off the whole very clean; then collect and weigh it.

2. If you roast the Residue in a Crucible till smoaks no longer, or rather in an earthen flat Vessel not glazed, and in a strong Fire to be stirred now and then with a Poker, and then weigh it when grown cold, you will be able to know, how much Arsenick remained in it in the close Vessel; unless the Ore contained Bismuth.

The Use and Reasons of the Process.

1. Arsenick is of itself more fixt than Sulphur, and is very strictly united to several Metals, Earths, and Stones, not even excepting Glass itself, and vitrescent Stones, and Salts: So that it remains with them, though melted in the most violent Fire, evaporating but little, and carrying Part of them away with it, when expelled by a violent Action of the Fire and Air: Which appears very plainly in the *Cadmia Fornacum*, or Tutty. The Glasses in which it is sublimed, are also penetrated by its Vapour, so that they grow milk white throughout their whole Substance: Which evidences its penetrating through all Bodies. It melts with many of the *Matrix's* in which it lies hidden, when you suddenly apply to it a middling melting Fire: Thus in the white Pyrites, which can hardly be conquered by Fire alone, because of the little Quantity of martial Earth and great Quantity of unmetallick Earth it contains, it turns to a Mass in Appearance of a semi-metallick reguline Nature, but not so in reality: Because a great Part of it is unmetallick, and difficult to be separated from the Arsenick, unless you use a Fire increased by Degrees, which at last forces the Arsenick to abandon the fixt Part of it. The same happens with almost all Metals and Semi-Metals; nay, it adheres also to their Scotia's and Calx's, it melts with them, and cannot be separated otherwise than by a slow Roasting. Arsenick is well fixt in pure Earths, and brings them to a Fusion without any Metal: For this Reason, when it is sometimes in small Quantities

ties in Spaads, Marles, &c. it exhales nothing in a gentle Fire, and in close Vessels: But in a strong open Fire, it at last spreads an unpleasant arsenical Smell, and diminishes the Weight of the whole concrete Body. Whence those who try to make Parget with Spaad, get sometimes Illnesses, while they bake their Parget, and their Moulds to cast Metal into: For this Reason likewise, Spaad and Parget made with it, which is done with a gentle Roasting, sometimes melts in a strong Fire; whereas it could not otherwise be brought to it by a great Fire. The Efficacy of this Body is very great in promoting dry Solutions, and it is considerably increased, when it is joined with a Body fixt in the Fire, and fusible; for Instance, with plain Glass of Lead, or with Glass made of Lead tainted with Arsenick, the Effect of which is much greater than common Litharge, or Glass of Lead. You may find out in close Vessels the Presence of Arsenick lying in a small Quantity in any Body whatever, by grinding it together with mineral Sulphur, and then subliming it, using a strong Fire in the End of the Operation: If there is then some Arsenick, there will arise, towards the End of the Operation, some Flowers of an Orange-colour, and a half-transparent ruby-coloured Sublimate, in which the Arsenick lies hidden: For this is raised along with the volatile Sulphur; whereas it could not otherwise be easily detected by Sublimation. But in Orpiment, which, besides the Arsenick, contains a Quantity of Sulphur not inconsiderable, the Earth which in this Mineral contains hardly any Metal, is melted together with them in a gentle Fire, and turns to a half-transparent red Mass, out of which you may, by a gentle Sublimation, or by Means of a Despumation, separate this Earth, which contains a great deal of Arsenick fixt in it, not to be dissipated without a great open Fire, increased by Degrees, and continued long.

2. The Phlogiston added, and the Fire applied in various Manners, give Arsenick a Variety of
outward

outward Forms: Otherwise, Arsenick is but one and the same, so it be but pure. When perfectly pure, it is of a white Colour: When joined with a Phlogiston, it becomes of a grey, blackish, ash-colour: And this is true not only of sublimed, but also of native Arsenick: As it is plain in the native black Arsenick, called in German *Schwartzzen-fligenstein*, out of which a grey Kind of Arsenick is produced by Sublimation. Arsenick sublimed with mineral Sulphur, is always of an orange, yellow, or red Colour, But the Phlogiston is easily detected in Arsenick both sublimed and native, when you reduce this to Powder, and cast it upon Nitre melted in a Crucible: For then you see a bright Flame and Detonation, which is produced by the least Quantity of any Kind of Phlogiston whatever, mixt with Nitre. They, indeed say, that Nitre detonates with Arsenick; that it produces a Flame, and that then the blue Spirit of Nitre of *Stabl* is expelled at the same Time: But pure, white, crystalline Arsenick, gives no Flame with Nitre; though it has the other Properties mentioned. You must make the Experiment about this Matter, with the following Precautions. Reduce a few Ounces of the purest Nitre into Powder, and put it into a deep wide Crucible: Put the Crucible into a wind-Furnace, and add gradually hot burning Coals that have ceased to crackle, lest the Vessel be split: nor must these Coals be heaped up higher than half the Height of the Crucible, which, mean while, must be covered against the Fall of burning Coals into it: When the Nitre melts in such a Degree of Fire as makes it grow moderately red, add at several Times Powder made with a solid Bit of white crystalline Arsenick: A noisy Ebullition is immediately produced, so that sometimes the foaming Nitre runs over a large Vessel; a Fume is emitted which is arsenical at first, and afterwards perfectly of the smell of *Aqua Fortis*; which being received through a hollow Retort into a Glass Recipient applied to it, resembles much the penetrating Spirit of Nitre. You must

must be cautious in this Process, not to use small Bits of Arsenick dispersed in small Chip-Boxes, or wrapped up in Paper. For the minuteſt animal or vegetable Fibre makes a pretty impetuous Deſlagration with Nitre melted or burning: For which Reason alſo, you are to use the cleanest Tools; lest any Phlogiston should get into it. Next, make the Operation under a Chimney, which carries Smoak very well; lest a noxious Vapour should annoy you. If the Mixture of Nitre and Arsenick is once put into Vessels well luted, to distil the above-mentioned Spirit; by increasing the Fire, the Mixture breaks the Vessels asunder with a Noise, just as if a Phlogiston had been mixt with the Nitre, resembling a true Deſlagration, not without some Danger for the People that stand by.

3. The Consistence of Arsenick varies, and chiefly depends upon the Fire applied to it. For Instance, if an arsenical Vapour finds a cold Place, it applies itself to solid Objects in Form of a Powder, as Sulphur does, which Powder is more subtiler in Proportion as it is more remote from the Fire. Arsenick is collected under this Form in large Operations, which are made, while the arsenical Ore is thrown into the Furnace with the Fuel of the Fire, out of which Furnace the Smoak is laterally conveyed through a Funnel, into a large Channel made with wooden Boards. This Channel is several Fathoms long: Nor is the Direction of it strait, but forming several Elbows, to the End that the Smoak may meet with more frequent Obstacles, by which being retarded it may apply itself, while the rest goes out at last, through a wooden Funnel constructed at the other Extremity of the Channel. This Powder is called in German *Gist-mehl*, and it has a grey or ash-Colour, caused by the Smoak of the Fire. But if it is sublimed in a covered Vessel, lest it should fly away too freely, the arsenical Flowers begin to grow clammy, in that Part of the Vessel which is at last made hot by the long Continuation of the Fire, and gather into a ponderous thick Sublimate: Nevertheless,

theless, this Sublimate does neither run out, nor get to the Bottom of the Vessel, when the Fire is increased: For a tenacious doughy Clamminess is indeed communicated to Arsenick by too violent a Fire; but Fire alone cannot make it melt, since it, on the contrary, resolves it most quickly into a Smoak, which finding no Way to escape, breaks asunder the Vessels that keep it confined. The yellow Arsenick assumes more easily the solid Form of Sublimate; on Account of the tenth or twentieth Part of Sulphur mixt to it, by which Arsenick is brought to a State of Fusion. But the red Arsenick, which is mixt with a still greater Quantity of Sulphur, cannot even be conveniently prepared in a Sublimation by Ascent, on Account of its too great Fusibility, which is communicated to it by an Abundance of Sulphur: But it adheres either above in Form of Flowers; or runs quite melted to the Bottom of the Vessel, leaving only a thin Crust of red transparent Sublimate, and some small Drops. Therefore, in order to be able to prepare it quicker, and in larger Bits, it must be forced out of a Retort; in the warm, large, though not too long Neck of which it must be condensed, and thence fall as yet fluid into the Recipient applied to the Retort, and grow cold. Arsenick of this Kind may be produced immediately out of Pyrites, without any Addition, if a sulphureous Pyrite is intermixed with a white Arsenick one, or with some other Arsenick-Ore, or added to it for that Purpose. And thus you will have yellow or red Arsenick, according to the Quantity of the sulphureous Pyrites.

3. In all Operations made with Arsenick, you are to take Care not to take in the least Quantity of it, either in Substance or in Form of Fumes, nor even to touch it frequently with your Hands: For it is a most pernicious Poison; even when taken in a small Dose it is mortal with most dreadful Symptoms, and when now and then applied in a very small Quantity, it produces Effects, which at last prove incurable: Whence a great many have lost their Lives,
for

for having managed it without Caution. Therefore, let all Processes with Arsenick be made under a Chimney that carries Smoak well: For the Vapour of Arsenick is not so quickly condensed, but something of it escapes through the Joints of the Vessels, and fills the Air with a Poison, which betrays itself, by its unpleasant garlick-like Smell. It is still more dangerous, when to be reduced to a fine Powder: For notwithstanding its great specifick Weight, when the Powder is violently agitated; it is easily carried away by the Air, not affecting the Smell nor the Taste, but yet pernicious, if drawn into the Lungs together with the Breath.

PROCESS LXX.

Mercury separates mineral Sulphur from Arsenick.

APPARATUS.

1. **L**ET the Arsenick be reduced to a most subtile Powder by a slow Trituration: Which is very conveniently performed in a stone-Mortar. This done, pour upon it a few Drops of Mercury: Continue the Trituration, the Mercury will insensibly disappear, and the fine yellow or red Colour of the Arsenick will be darkened: This done, add some more Mercury without ceasing the Trituration; till at last the Powder receives no more Mercury, and there remains not the least Appearance of the yellow or the red Colour in the Mixture, but it assumes either a grey Colour, if there was but very little Sulphur in the Arsenick, or a black Dye, if it contained a good deal: Which can hardly be done in some Hours, if you employ a Pound of Arsenick. But in this very Case, it is proper to perform the Trituration in separate Parcels.

2. Fill

2. Fill about one third, or one half Part of the Belly, of a high, narrow glass-Cucurbite, not cut off: Apply to this, instead of an Alembick, another large inverted Cucurbite, cut off at Top, and stop the Joints with Lute: Put it into a Sand-bath, in a Situation somewhat oblique: Nor must you gather your Sand around it, higher than the Mixture in the Cucurbite: Then perform the Sublimation, in a Fire somewhat gentler than Cinnabar requires: The arsenical white Flowers will adhere above, together with neat white Crystals of Arsenick, or they will be grey, and the sublimed Cinnabar will be lower, nor will this, however, be altogether void of Arsenick.

The Use and Reasons of the Process.

1. A great Quantity of Sulphur melted with Arsenick, may be separated from it for the greatest Part, by a gentle Sublimation (*Proc. LXIX*): But a Part of the Sulphur is so strictly detained by the Arsenick, that they can never ascend but both together; in such Manner however, that the first Sublimate and the Flowers are richer of Sulphur, while that which ascends last, contains little or no Sulphur at all: But this requires a gentle Fire slowly increased.

2. A more perfect Separation of Sulphur and Arsenick is obtained by Means of Mercury, and even at first the Sulphur is joined to the Mercury the cold way, by Trituration alone: Which we learn from the Production of the *Æthiops Mineral*, which being afterwards sublimed by Fire, turns to Cinnabar. But this Experiment will never succeed to your Satisfaction, unless the Trituration of the Arsenick with the Mercury is very well performed: For else, when the Fire begins to act, there ascend first of all Flowers of an Orange-colour, on Account of the mineral Sulphur, which Flowers are more volatile than the pure Arsenick that follows and fill the upper-Part of the Vessels, spoiling the said Arsenick; because
the

the Sulphur was not yet united with the Mercury : Therefore, you must add rather more than less Mercury, that all the Sulphur may be detained. Next let the Fire not be too violent nor too precipitately applied, because it confounds all the Ingredients together : Nor must the Necks of the Vessels be too large. However, as Arsenick is employed pure for other Uses, this Separation is never made; because it requires a great Labour, and yet is never completely performed. For a great Quantity of Arsenick, separated from the Sulphur, adheres to the white, shining, solid, distinct, small Masses, which are between the Sublimate of the Cinnabar, and the small Drops of the Mercury that have not been dissolved by the Sulphur. Whence, the Cinnabar appears rather of a grey than a red red Colour, and may at last be totally separated, by repeating and well performing the Sublimation.

3. The Foundation of this Process is then, that Mercury is dissolvable by Sulphur, and on the contrary rejects Arsenick. Therefore, as the other Metals and Semi-metals have an equal Affection for Arsenick and Sulphur, or reject them both, the Separation of the latter by the former will not succeed ; or if any Kind of it is obtained, it happens in an inverted Proportion ; for Instance, when the Sulphur ascends easily, the Arsenick is detained in the *Caput Mortuum*, which is dissipated by a strong and commonly an open Fire : If any is obtained, it is generally not true, and impregnated with Phlogiston. See *Henckel. Pyrit.* p. 558.

P R O C E S S LXXI.

The purifying of Arsenick by Sublimation with a fixt Alkali, to make it white and crystalline.

A P P A R A T U S.

IF instead of Mercury (*Proc. LXX.*) you use a fixt Alkali well burnt, such as Pot-ash; there comes forth a half-transparent, white, solid, hard, ponderous Sublimate of Arsenick, which adheres below, and pulverulent white Flowers join to it above. But the Fire, must be much more violent in this Sublimation than in the foregoing, especially towards the End: Wherefore you must also chuse higher Vessels, that the arsenical Vapours may find a Space less warm to which they can apply themselves. You are also to take Care, not to add more Alkali than is necessary to retain the Phlogiston: Which cannot be exactly determined: For you will obtain Arsenick with greater Difficulty, and in lesser Quantity, as you use a greater Quantity of Salt, and on the contrary.

The Separation of the Phlogiston will succeed with a small Quantity of Arsenick, if you first sprinkle the Atsenick reduced to a very fine Powder, with a very pure alkaline Solution, and then dry it slightly before the Sublimation. Likewise more Arsenick is produced by this Method in a gentle Fire.

The Use and Reasons of the Process.

1. Fixt Alkali well burnt in an open Fire is very greedy of a Phlogiston, if you except Acids and Water on certain Conditions, and when it has absorbed it, it does not entirely quit it again easily, unless you hinder the too free Action of the Air; let the Violence of your Fire be ever so great: Which may

may be experienced in the Distillations of Tartar and of common Soap, and in the Operation made with reducing Fluxes; wherein there remains always something of the Charcoal. Arsenick, with the least Quantity of Phlogiston, assumes a grey, ash, and black Colour, or the orange or red Colour, when Acid of Vitriol is added to the Phlogiston. When the Phlogiston is expelled, it appears again under its white Colour. When white, it is again defiled with the said Colours, by a small Addition of Phlogiston, if it is first digested with it, and sublimed again, as the above quoted Author says, with Oil of Almonds. Vid. *Pyritolog.* p. 558.

2. But the Phlogiston is not only detained by a fixt Alkali; but a great Part of the Arsenick itself is also fixt by it to such a Degree, that it cannot be intirely dissipated out of it by any Fire, not even an open one; and even turns to Glass with it by adding some Flints: Therefore, fixt Alkali must not be added too liberally. Thence it is plain, that this Separation of Arsenick and Sulphur does not take Place, if the latter is mixt in too great a Quantity with the former; and that you must have Recourse to other Remedies. See *Proc.* LXX. and LXIX. But a smaller Quantity of Salt is sufficient to separate the same Mixture of Arsenick and Phlogiston, in Proportion, as all the Ingredients are more intimately mixt together: Which is better obtained by a Sprinkling with an alkaline Solution, than by a dry Trituration: Because all the small Masses of Arsenick are surrounded and penetrated with the Salt in the former.

3. It is wonderful, that this Separation of the Phlogiston and Arsenick can hardly be completely performed by any Body, besides fixt Alkali, unless by Mercury (see the above-cited Place); although there are much more potent Magnets of inflammable Matters, than Mercury is. The Thing cannot be done at all with Metals; nay, the purest white crystalline Arsenick, sublimed upon Metals that are gra-

nulated, or filed very fine, (pure Gold and Silver excepted) ascends rather the sooner, and is sullied with a brown Colour, of which it must be again purified by the foregoing Method.

4. As the remaining alkaline Salt is still impregnated with no small Quantity of Arsenick; it is very good to make white Copper, and to impregnate the other Metals with Arsenick: For which Purpose, some prepare fixt Nitre by a Detonation with Arsenick (see *Proc. LXIX. Use. N^o. 2.*) in which Nitre a great Quantity of Arsenick is fixt, which being afterwards melted with Copper, gives it a white Colour*. By which Means a considerable Malleability is preserved in the Copper.

P R O C E S S LXXII.

Arsenick is reduced into a semi-metallick Form, with a Phlogiston.

A P P A R A T U S.

1. **G**RIND together two Parts of white, crystalline Arsenick finely pulverised, or of the Flowers of it, with one Part of the black Flux, one half Part of Sandiver, and as much of Filings of Iron not rusty, that they may mix well together. Fill with this Mixture a strong wide Crucible, and cover it with common Salt one Finger's breadth high: Then, cover it with a Tile, or an inverted Crucible having a small Hole in the Middle. Put it in the Wind-Furnace. Make first a gentle Fire, that the Vessels may warm equally. When the Arsenick begins to smok, increâse the Fire suddenly, that it

* This is the white Prince's Metal, invented by Prince *Rupert*, of which Buckels, Spoons, and many other Utensils are made, to imitate Silver; but they soon tarnish; to mend which they cover over this Metal with a thin Coat of Silver, and polish it, which is sold by the Name of *French Plate*.

may be of a moderate melting Degree, and put the Mixture in Fusion: This done (which may be found out with an Iron-wire introduced through the small Hole bored in the upper-Crucible) take the Vessels out of the Fire, put them into a cold Place, and, when cooled, break them: You will find a *Regulus*, which will be more soft, more brittle, and of a darker Colour, in Proportion as it doth contain more Arsenick, and less Iron. On the contrary, if a great deal of the Arsenick has been dissipated, because of the too slow Application of the Fire, it will then be harder, more solid, and whiter. It may also be poured into the melting Cone, when the Mixture is in greater Quantity: And being thus sooner cooled, so great a Quantity of the Arsenick is not dissipated.

2. *Regulus* of Arsenick may be prepared with Copper after the same Manner; which, retaining likewise a great Quantity of Arsenick, will, on this Account, be very brittle, and of a dark Colour; but, when the Arsenick is in great Part dissipated, it will be neater and harder, sometimes as brilliant as Silver, half-ductile, with a very slight yellow Cast. This is a kind of whitened Copper.

3. Arsenick intimately mixt with Flux, warmed first slowly, and at last melted suddenly, though not with too great a Fire, is collected into a *Regulus* of a semi-metallick Kind, but soft, light, and pretty bright, though not of a lasting Colour: Nay, the fine Brightness it has at first when broken, vanishes in a few Days and turns black, though not throughout the Mass, but only at the Surface. This *Regulus* being brought near a Candle, without any Addition of Arsenick, seems to nourish the Flame, like the red Arsenick charged with Sulphur, and vanishes at the same Time into a pernicious Smoak, in which it may be thus totally resolved: This Smoak gathered under the Form of Flowers, is the grey Arsenick (*Proc.* LXXI. and LXX.) These Processes must be performed under a Chimney that carries the Smoak

well, lest the poisonous Fumes, coming forth with great Violence, should prove hurtful to the Artificer.

The Use and Reasons of the Process.

1. Copper and Iron render the Precipitation of the *Regulus* of Arsenick abundant and easy in this Process, but they do it from another Cause than in the Production of the *Regulus* of Antimony. For in the latter they were added, that the mineral Sulphur, which retained the reguline Part dissolved in crude Antimony, might be absorbed by them; which done, the *Regulus* rendered free went to the Bottom, while the Metal that was in the Mixture charged with Sulphur, swam at Top in Form of Scoria's. But, in this Operation, Arsenick, which is of itself altogether volatile, must be exposed to a very violent Fire suddenly applied, that it may be fixt with these Metals, after having been reduced to a semi-metallick and very volatile *Regulus*. Whence it is likewise self-evident, that the *Regulus* of it participates very much of any precipitating Metal whatever, and is less uncompounded than the *Regulus* of Antimony precipitated by Metals, and that of Course it cannot be purified again by way of Fusion: For it is presently resolved into Fumes, as soon as it is separated from the Metal that fixes it.

2. If this *Regulus*, precipitated with Copper or Iron, is beaten to a coarse Powder, and then a great Quantity of it is sublimed, the semi-metallick arsenical Part is for the greatest Part carried up, and must be looked upon as the purest reguline Substance of Arsenick: For there remains at the Bottom of the Cucurbite, that Metal by which the *Regulus* has been precipitated; but it is tainted with a great Deal of Arsenick: Nor can it be dissipated otherwise than by repeating the Roasting and the Pulverising, in an open Fire increased by Degrees. See particularly the Processes about *Iron* and *Copper*.

3. The

3. The *Regulus* of Arsenick is very difficultly got without any Addition. For every reducing Flux is very refractory, with regard to the great Volatility of this *Regulus*, so that it is most quickly dissipated by the same Fire that melts it, and then either disappears intirely, or adheres dispersed among the Scoria's, to small shining spongy Masses: Which happens also, when there is not the Degree of Fire necessary for the Fusion of the Flux. There is also a great deal of the Arsenick that remains in the Scoria's totally dissolved, and not apparent at all. For this Reason, there must be much more Arsenick than Flux, and they must be mixt together by Trituration; the stricter, the better. Arsenick may be produced under a semi-metallick Form, out of the same Mixture of Flux and Arsenick, by a strong Sublimation: This may be done very conveniently with a small Earthen Cucurbite, to which another of Glass must be applied: This must by all Means be horizontally situated in a Furnace fit to make Distillations in an open Fire, which being strongly increased, the Arsenick ascends, and applies itself to the colder Region of the Vessels, partly in blackish thin-set Flowers, partly in a Sublimate composed of a Collection of small scaly shining Masses.

4. Let Arsenick be reduced to a semi-metallick Form, by whatever Method you will, according to the foregoing Directions, it will re-assume its white crystalline Form, by a Sublimation with fixt Alkali, or Mercury (*Proc. LXXI.*)

OF VITRIOL.

PROCESS LXXIII.

*To extract Vitriol out of the Ink-stones (Part I. § 421.)
and to crystallize it.*

APPARATUS.

1. **A**N astringent, rough, sweetish, styptick, nauseous Taste, betrays the Presence of some Vitriol, or Allum, in any terrestrial Concrete. Now, if you want to be certain, what this Concrete is, and how much it conceals of the said Minerals, beat the Clod of Ore to Powder, and boil it in a Glass-Cucurbite cut off at Top, or in a Vessel made of milled Lead, with three Times the Quantity of pure Water. Stir up the turbid Water still warm with a wooden Stick, pour it into a double filtrating Paper, previously moistened with Water, and placed in a Glass Funnel: This must be done, lest a great Quantity of the Water which contains Vitriol, escaping at the upper Part of the filtrating Paper, should diminish the Product considerably, especially if you use but a little of the Ink-stone. Let the pulverized Clod of Ore be boiled a second Time with a double Quantity of Water, and repeat this so long as the Taste of the Vitriol is strongly perceived in the boiled Water: Then filtrate these Solutions, and pour them upon the first Solution.

2. When all the Solutions are collected in a Glass Cucurbite, cut with a wide Opening, put them in a Sand-bath, and make a Fire so strong as that a thick Vapour may come out, but the Fluid not boil: Continue this Degree of Fire equally, and without Intermission: So soon as you see thin Pellicles on the Surface of the Solution, like Dust that might have
fallen

fallen upon it, swimming at Top, let the Vessels grow cold, and put them in a cold still Place for one Day and one Night, that Crystals may gather, which must be collected by decanting the remaining Liquor of the Solution. Dilute the Residue with the double Quantity of Water, filtrate and inspissate it, and set by for Crystallization, as before; till what remains at last refuses to turn any more to Crystals, but assumes an oily Consistence. Consider every Time separately the Crystals produced, to see whether they have the Properties of Vitriol (Part I. § 417). But in each Crystallization, an Oker of a yellow Colour will be produced, which is expelled in a greater Quantity, as the Inspissation is performed more slowly and inequally, or even when the Solution is kept too long at rest, though it be perfectly transparent.

The Use and Reasons of the Process.

I. There are many Ink stones that conceal different Kinds of Vitriol confounded together (Part I. § 417.) and sometimes Allum into the Bargain. The latter is very easily distinguished, when the Inspissation and the Crystallization are discretely performed: By which Method some Salts may be separated from each other, which being confounded with an Inspissation too hastily made, cannot be well distinguished. The Difference which, is between these Vitriols, proceeds from a Variety of the Proportion, in which the green Vitriol of Iron * and the blue Vitriol of Copper † are joined to each other. Allum itself mixes with them pretty often, which appears clearly, if you distil Oil from Vitriol, or calcine this strongly, and edulcorate with Water the *Caput Mortuum* which is very red. This Water being inspissated and crystallized, produces whitish Crystals, which are called *Gilla Paracelsi* ‡, and have concentrated in them the Allum

* In the Shops called Copperas.

† Known by the Name of *Roman Vitriol*, or the blue Stone.

‡ Salt of Vitriol.

which was in the Vitriol. Nay, this *Gilla* is more impregnated with Copper, than the Vitriol out of the *Caput Mortuum* of which, it has been made. For Allum most difficultly loses its Acid in the Fire: Therefore, if you pour Water upon it, after a strong Calcination, it may be reduced almost totally to Crystals again. Likewise, Copper is not so easily deprived of all its Acid by Fire, as Iron is, though the former be precipitated by the latter.

2. The Vitriols of Iron * and of Copper may easily be produced by Art, and even that of Iron by simply pouring upon it Oil of Vitriol, diluted with six or eight Times as much Water, when it is too much concentrated (*Part I. § 109*) But the Solution must be left for one or two Days in a moderate Heat, and more Iron be added than the Oil of Vitriol can dissolve. Then, when the Solution is thoroughly separated, filtrate it, evaporate it, and reduce it to Crystals as before, and you will have green Crystals: This Solution also lets fall a great Quantity of yellow Oker during every Inspissation; and even when you let it rest for one or two Days, it grows opaque, and assumes a rusty Colour. But, if you let fall into it a few small Drops of Oil of Vitriol, to make it very slightly acid, it remains long limpid, and if it is inspissated and put at rest for a Crystallization, this yellow martial Earth doth not subside: The Crystals which are then produced, become less yellow, of a Grass-colour, and keep their Whiteness and Transparency longer, but are a little more acid. Thence it is plain, how vain is the Labour of those who try to purify the Vitriol of Iron, by these repeated Solutions, Inspissations, and Crystallizations. For it is totally resolved into these Okery Dregs, and if it contains any Copper, there remains at last almost mere Vitriol of Copper.

* Vitriol of Iron is called *Copperas*, and is made in great Quantities at *Deptford*, near *London*, of rusty Iron, old Nails, &c. and Pyrites.

3. If you throw a little Filings of Iron into [a Solution of] Vitriol made with Ink-stones or Pyrites, the Copper, if it contains any, is precipitated to the Bottom; so that with regard to it, it is as pure as the factitious Vitriol of Iron (N^o. 2.)

4. Vitriol of Copper is prepared in an instant with Oil of Vitriol as (N^o. 2.): But, this is not so much saturated with Metal: For Copper does not so readily yield to Oil of Vitriol, as Iron does. The Operation succeeds better, if you stratify Plates of Copper with Sulphur in an Earthen-Vessel, shut close with a Tile and with Lute, and then put the Vessel into the Fire, till it is middling red-hot. Thus the Plates are corroded by the Sulphur, and become of a dark Colour, and much thicker than they were before: This is called burnt Copper. The Copper, being penetrated by the Sulphur, is afterwards roasted in a moderate open Fire, till you no longer see any sulphureous Flame: Thus by pouring Water upon it you may get a very fine azure-coloured Solution of Vitriol of Copper, which must be reduced to Crystals.

P R O C E S S LXXIV.

The making of Vitriol out of the Ores of Iron and Copper.

A P P A R A T U S.

1. **A** Very great Quantity of common Vitriol, such as is sold in the Shops, is got out of Pyrites: Some of them having very little or no Copper in them, when exposed to the Air, turn of themselves to Ink-stones. These are merely charged with Sulphur, and very little arsenical. However, they do not all so easily turn to Vitriol: And some of them will not do it at all. They must be beaten to a coarse Powder, and thus exposed to a pretty moist Air, till

till their outward pyritose Brightness and Hardness do totally disappear, and even the inward when they are beaten afresh. Do the rest as in *Proc. LXXIII.*

2. The other Pyrites, among which some are coppery, and impregnated with a great Quantity of Arsenick, and many purely ferreous and sulphureous, require a previous Roasting. This is performed either in close Vessels (by which Operation the Sulphur is collected together (*Proc. LXVII*); or in a moderate open Fire. The Vitriol is not yet generated in some of them; but they must be first exposed to an open somewhat-moist Air, as No. 1; or if the Air is too dry, you promote the Production of the Vitriol, by now and then sprinkling them very slightly with Water. Then the Vitriol is produced sooner or later in the several Pyrites. But some afford Vitriol immediately after the Roasting, though in a much smaller Quantity, than when they are afterwards exposed to the Air in the Manner above-mentioned. Then wash the Vitriol clean. If you expose again to an open moist Air what remains of the Edulcoration, which is called the *Caput Mortuum*, it is commonly still impregnated with Vitriol, but in a much lesser Quantity.

3. There are many Stones of Calamine, which yield a no inconsiderable Quantity of Vitriol, immediately after the Roasting: Nor is it necessary to expose them any more to the Air.

The Use and Reasons of the Process.

1. We ought here to give the Reason, why some Pyrites turn of themselves very easily to Vitriol, when only exposed to a free Air, some with greater Difficulty, and a great many not at all, even in the Space of many Years together: And again, why some Pyrites presently yield as much Vitriol as can be got out of them, when washed in warm Water, while some must at several Spaces of Time be again exposed to a moist Air after the Roasting; tho' this

this Matter has not been examined so closely, but there remain still many Doubts about it. I shall here in a few Words mention the Discoveries Dr. *Henckel*, the Author so often quoted, has made by a Multitude of Experiments, and communicated to us in his *Pyritology*.

Viz. No Pyrites, containing any Copper or Arsenick, turn of themselves to Vitriol, but they require a previous Roasting.

The sulphureous Iron-Pyrites, void of Copper and Arsenick, turn to Vitriol by the Action of the Air, and of the Things it contains, and this the quicker, as they are less compact: Such are chiefly those which seem to consist of a Multitude of Fibres and *Radii* gathered together. But there are a good many Exceptions to this: For there are Pyrites of such a Kind, that they persist unchanged for whole Years together.

Therefore we see Copper and Arsenick resist this Alteration of the Pyrites, and it likewise follows, that there is another secret Cause hitherto unknown of this Constancy of the Pyrites, because the Pyrites which are merely ferreous and sulphureous, do not at all turn to Vitriol of their own Accord. I have exposed such Pyrites, moderately pulverized and not very hard, to the Injuries of the Air for whole Years together, but they persist unchangeable to this very Day.

2. It is still less known, why Vitriol is found in some Pyrites, if you but pour Water upon them after the Roasting, while you find none in some others, unless you have exposed them previously to the Air, at different Times. It even seems that we are to look in the Air for the Reason of this, as it carries moist Vapours with it. And indeed the Acid of Sulphur has not the Virtue to resolve Iron into the Form of Salt, without a sufficient Quantity of Water: Nay, Oil of Vitriol or of Sulphur itself, being moderately concentrated (though diluted with much more Water, than it is when united still with Sulphur)

phur) does not even dissolve Filings of Iron, unless you pour four or six Times as much Water upon them. But, the Thing being well considered, it is certain, that there is still some other hidden Cause of this; because it is not conceivable, why Water, poured upon some Pyrites, does immediately extract Vitriol out of them, and none out of some others; and again, why some crude Pyrites turn presently to Vitriol in a free open Air, and never when immersed under Water. I have met with such sulphureous and ferreous Pyrites on the Shore of the Northern Sea, that shewed no Sign whatever of Arsenick and Copper, neither before nor after their being changed to Vitriol. They were composed of parallel Fibres almost like Wood, very soft, and of a fine Brightness; But they were covered with a coarse Sand some Feet deep, which the Water of the Sea could penetrate easily enough, and they had no Manner of Taste, and consequently were altogether void of Vitriol. But after they had been exposed to the Air for a Fortnight, they lost intirely their Brightness, and were become so rich of Vitriol, that small green Crystals of the Size of Millet-seeds appeared on their Surface. Now if the Moisture alone was sufficient to produce this Effect, there is no Reason, why they should not have been resolved into Vitriol under a very moist Sand. There remains still a wandering fossile Acid, which fills also the aerial Region. Many affirm, indeed, that this concurs to promote an abundant Production of Vitriol, nor must we by any Means exclude it entirely, no more than the Moisture of the Air. But whoever seriously considers what has been said before concerning this, will own that there are some Conditions requisite for the Production of Vitriol, which we do not as yet clearly understand.

3. We might here add something concerning white Vitriol, and the other Species of factitious Vitriols; but we shall treat of these more at large on another Occasion.

OF ALLUM.
PROCESS LXXV.*Preparation of Allum.*

APPARATUS.

1. **T**HE Minerals of Allum, as well as those of Vitriol, must be prepared many different Ways, to get Allum out of them. For there are some alluminous, fat, bituminous Minerals, which, being heaped up in the Air, grow warm, smok, crumble, and sometimes take Flame; but this is not done without some Loss of the Allum, and it must be prevented, by pouring Water upon and disjoining the concrete Heap: They finally separate, and assume the sweetish, styptick, nauseous Taste of Allum, which before was but little or even not perceived at all in this Mineral. Some barren Minerals, as well as the Pyrites, require a gentle previous Roasting, which being done, the Allum is at last produced. Chuse out of this Heap a Specimen of some common Pounds, put it in a Lead or Glass-veffel, and pour upon it three Times as much Water: Make it boil, and strain it through a Filtre; pour again warm Water upon it, and make it boil another Time, that the remaining Earth may be well edulcorated. Pour the Solutions together, and let them rest for one Day and one Night together, that the Dregs may subside to the Bottom; or strain it again through the Filtre: Then let the clear Liquor be so inspissated as that it may sustain a new laid Egg put into it: Let it grow cold again, and rest four and twenty Hours: At last you will see what will be precipitated: For Crystals of Vitriol are sometimes produced; and sometimes the Allum is expelled. If

it is Vitriol, you must throw it away : But the Allum must be purified by a repeated Solution and Crystallization, which will be of a reddish bay Colour. Continue the same with what remains of the Solution, till it is intirely exhausted of Allum.

2. But if no Allum is precipitated, the Solution must again boil on the Fire, then pour into it about one twentieth Part of saturated Lye of Pot-ash, or one third Part of purified Urine, or also some Quick-lime: Mean while, continue to boil it: If there is any Allum, a white Precipitate will begin to be expelled, when the greatest Part of the Solution is consumed : Then let it cool and rest, and decant the Solution from what is precipitated, and out of this remaining Solution the rest of the Allum will be precipitated in the Manner already mentioned, till there remains at last a thick Liquor void of Allum. This done, dissolve again, in a sufficient Quantity of boiling Water, all that has been precipitated, purify it by letting it rest, or by Filtration, and reducing to Crystals according to *Proc. LXXIV.*

The Use and Reasons of the Process.

1. Allum, precipitated by itself, consists of a mere Earth, reduced into a Form of Salt by a vague fossile Acid. But this Earth is of a most singular Nature, and different from the other native Earths that are known. For, with Chalk, Lime, and Spaad, dissolved in this Acid, you will produce Salts somewhat like Allum, though never perfectly resembling it. But, if this Earth is of that Kind, the Allum is white, or of a light reddish Colour : And when a Metal mixes to it in the Form of Vitriol, it is tinged with a bluish greenish Colour : And the Allum in this Case must be looked upon as impure. But, if the Precipitation of Allum is performed by a Solution of a fixt Alkali, or of volatile putrid Urine, then, indeed, as well as in all Precipitations, a great Deal of the precipitating alkaline Salt joins to the Allum : Which

seems

seems to be the Reason why Allum is so lasting, such as are the Crystals composed of Alkali, and of the vague fossile Acid united together, and will not easily abandon its Acid in the Fire. For when it is made middling red-hot in the Fire, there comes out a very little Quantity of Acid; and if it is afterwards tormented by the greatest and longest Fire, you can never extort any more of it; so that on this Account, the *Caput Mortuum* is most commonly looked upon as mere Earth, which nevertheless is in the greatest Part dissolvable by pouring hot Water upon it, and may be almost totally reduced again to its Form of Allum, by a reiterated Evaporation and Crystallization. But the Alkali is poured upon it not only because of the Precipitation of the Allum itself, but also because of the Separation of the Vitriol, which otherwise would be difficultly performed. You are to take Care at the same Time, not to add too much Alkali; therefore, it must be poured in by small Quantities, to be repeated several Times, till you are sure of a just Proportion. For the same Purpose, an Addition of Lime is not useless, and even must sometimes be substituted, for a greater Security. As for the rest, you must here make the same Observations as were made about Vitriol (*Proc. LXXIV*). The remaining Earths and Dregs, being exposed anew to the Air, are again impregnated with Allum, but not all of them.

These Processes about Allum, as well as those about Vitriol, do not always agree so exactly with those which are performed in greater Quantities, for a greater Proportion is commonly produced in larger Operations. For several Artifices must be used in every Case, which must be understood from the peculiar Nature of each Mineral, by repeated Experiments: Whence you must generally repeat a few Times these Examinations, before you are able to pass any certain Judgment.

OF NITRE.

PROCESS LXXVI.

The Preparation of Nitre.

APPARATUS.

1. **W**E have spoken of the Generation of Nitre, or Salt-petre (*Part I. § 437, &c*); there remains that we should treat of the docimastical Extraction and Purifying of it. The Preparers of Nitre, commonly throw a few Pounds of the Earth, in which they suspect there is any, into a wooden Vessel with double the Quantity of warm Water, and stir it several Times with a Stick: Then they put two small Copper-Dishes of equal Weight into one of the Scales of Balance that is pretty true, and a docimastical Centner into the other Scale: They put some of the Solution drop by drop into the former, till an Equilibrium is obtained. They put the Scale which contains the Solution upon the Ashes, or upon Sand that is middling warm, to make it thoroughly dry, and weigh it again, to know how much there remains of the Centner of the Solution of Salt. Then they take the Salt out of the Scale, and taste it, to see whether it is nitrous; and put burning Coals upon it, to try whether it will deflagrate; which shews you that the Nitre is pure, if there remains little or no Alkali at all; but if it decrepitates and flies asunder, you may judge that it contains a great deal of Salt, and then the Nitre proves the worse.

Another Method.

1. **Y**OU will find the Nature of it more exactly by the following Method. Take many common Pounds, for instance twenty or thirty, of nitrous

trous Earth, and mix them with once and a half as much of quick-Lime and alkaline Ashes, or add, instead of these, half a Pound of Pot-ash: Put these Things into a wooden Tub of a sufficient Capacity; pour upon them about the double Quantity of warm Water, and leave them thus for four and twenty Hours: It is proper to stir the Whole now and then with a wooden-Stick. Next, pour the whole Mass into a linnen-Bag: The Lye will first pass through turbid; pour it again into the Bag, to strain it a second Time; which done, it will be transparent and yellow. This done, let it boil in a large Kettle, till so much of the Liquor be dissipated, as that a small Drop of it let fall upon a cold Surface may congeal. Take the Kettle from the Fire, and let the Solution cool for one Day and one Night: You will see whether any Crystals (*Part I. § 21.*) are produced. Dilute the remaining Solution in the double Quantity of warm Water: Then inspissate it, and let it cool; Repeat the same as long as Crystals will be produced by the Solution: There will remain at last a thick fat Liquid, which may indeed be inspissated, but will not turn to Crystals, and easily runs to Water again in the Air.

3. If you are willing to have these Crystals very pure, dissolve them in eight Times as much Water; filtrate them through a Paper; add to them a few Drachms of Quick-lime, and make them digest with it a whole Day. Drop into this Liquor a few small Drops of an alkaline Solution. If, a little after you see small Clouds in the Solution, go on, till it is no longer turbid: It is never necessary to drop above half an Ounce into it. This done, filtrate it through a Paper; evaporate it in a short Glass-Cucurbite, and when you see a small Pellicle, let it grow cold. The slower it cools, the larger and finer the Crystals will be. You must always dilute the Residue with the double Quantity of warm Water, before you expose it to the Evaporation, and repeat the Crystallization, till the Nitre is entirely exhausted.

The Use and Reasons of the Process.

1. Nitre is produced out of soft Earths* impregnated with fat and saline Particles of vegetable and animal Bodies apt to come to a Putrefaction. But Nitre is never found perfect in them, unless fixt Alkali, or a limy Earth be joined to them. It is then proper to add alkaline Salts to the Earths in which Nitre is to be generated, or at least to mix alkaline Ashes or Lime to them, while the nitrous Earth is boiling for a Lye. For, it is certain from unquestionable Experiments, that these Things enter really into the Composition of Nitre. This is plain, from the abundant Quantity of Alkali that comes from Nitre by Means of a very small Quantity of Coals of Vegetables, having no fixt Alkali in them, such as proceed from Mustard seed, and the like: For if such Coals being put upon melted Nitre, detonate with it by increasing the Fire to a high Degree, and the Mass is brought to a Fusion like Water after the Detonation is compleated, you will have above one Half of fixt alkaline Salt, with regard to the Nitre employed; unless you have flung much of it out of the Vessels, on Account of their smallness, or by putting imprudently too much Charcoal at once. This Alkali is called *fixt Nitre*, and is a little less Fusible than any other pure fixt Alkali, because of the subtil calcareous Earth which is in it. Nor does there then remain any Vestiges of Nitre in it, which is detected by pouring in Oil of Vitriol to a perfect Saturation. For, if there remains any Nitre, this Residue will affect the Nose with an

* Large Quantities of Nitre are extracted at *Paris*, out of the Rubbish of old Buildings; which are thereall made of Stone and Stone-mortar. The greatest Quantities of Nitre, whereof the Consumption is now become so great for the making Gunpowder, are brought from the *East-Indies*; but it is not yet known to us whether it is an artificial Composition made by the Inhabitants of the inland Countries, or whether there really are any Mines of native Salt-petre, or any natural Earths, out of which it can be extracted.

Odour of Spirit of Nitre, by expelling the Spirit of it. This Presence of fixt Alkali in Nitre, is likewise testified by the Regeneration of it out of Spirit of Nitre and Alkali. Nitre agitated with a strong Fire, in a strong open Crucible, is at last dissipated in Form of Smoak (*Proc. XIV*); there remaining a very small Quantity of Alkali; which is, however, likewise dissipated by continuing the Fire, because it is not absolutely fixt. Moreover, the superfluous calcareous Earth, which has been introduced in a saline Form by the Spirit of Nitre, and is contained in the Lye, is precipitated by the fixt Alkali. This appears in great Quantities, especially in the last remaining Lye of the first Crystallization, unless it has been already precipitated, during the boiling of the Lye itself, by the Abundance of Alkali: It is called *the white Manganese*. But we are informed, by dropping in Oil of Vitriol, that there is Spirit of Nitre in this Residue; and if it is distilled with this Oil, the collected Spirits are *Aqua Regis*: Because there remains some common Salt in this Lye.

2. If Nitre is crystalized a second Time, it is still purer. The small Clouds which appear at the Instant of the dropping in of the alkaline Solution, proceed from the small Residue of white Manganese: But, the marine Salt is thoroughly separated by this second Operation, because it being easily dissolvable in Water does not turn so easily to Crystals, as Nitre: Therefore, the first Crystals are always purer than those which are produced in the Crystallization of the Residue: Which is confirmed by the Distillation of this with Oil of Vitriol (See N°. 1).

3. Mean while, take Care, never to make the Evaporation and Crystallization of the Salts in an earthen-Vessel: For, let it be glazed ever so neatly, yet, all Salts, even the fixt alkaline ones, are not only absorbed thereby, but even find so ready a Passage through them, that lanuginous Crystals surround the Vessel on the Outside.

OF COMMON SALT.

PROCESS LXXVII.

To try saline Waters.

A P P A R A T U S.

SAL-gem may be extracted simply out of Earths and Stones with warm Water. But saline Waters must be purified, by either Filtration, or Rest. Let several Pints of them be inspissated by a strong Boiling, till a thin Pellicle, or small Crytals appear on the Surface of the Liquor. Next, the Fire must be diminished, that the saline Brine may be only middling warm, and smoak: The Crytals which were small at first, will grow of a larger Size: They are of the Figure of a hollow, truncated Pyramid, open at the Basis, made of a Heap of small Cubes, which being become large at last sink to the Bottom of the Solution. But, if you use a stronger Fire, the whole Surface of the Brine will be covered with an unformed saline Crust, which hinders all further Exhalation, unless you break and precipitate it to the Bottom. When it is so far inspissated, as that the saline Crytals may be almost even with its upper Surface; you must decant the Brine from the subsiding Crytals, and this must be inspissated in the same Manner: The Crytals of Salt being collected, and dried by a gentle Heat, must at last be weighed.

The Use and Reasons of the Process.

You may plainly see from these Processes, how common Salt may be separated from other Salts easily turning to Crytals, and chiefly from Nitre. For some Salts are difficultly and in small Quantity dissolved

dissolved in cold Water, but they melt most quickly and in great Quantity in warm Water. Such are Nitre, Tartar, Tartar vitriolate, all Vitriols, Allum, &c. some of them melt easily enough and in good Quantity, equally in cold and warm Water; nay, even in the Air, when they have absorbed the Moisture of it: Add though they melt a little quicker in warm than in cold Water, yet the Difference is very small. Of this Nature are, common Salt, vegetable fixt alkaline Salts, and even several neutral Salts dissolvable in the Air. Therefore, the less the Difference of the Quantities of the Salts which are dissolved both in warm and cold Water, is, the less Quantity of Crystals you will get, and on the contrary. You will understand this better, if illustrated by an Example. Let Nitre be dissolved in cold Water, to a Saturation; and the Solution boil in an open Vessel: The Water will be so disposed by the Heat, as that a much greater Quantity of Nitre may be dissolved, besides what is already so: Which may be easily experienced. But, so soon as the Water begins to be dissipated into Vapours, it at last diminishes to such a Degree, that it can no longer contain all the dissolved Nitre, which being then at the Surface which is less warm, is nevertheless first of all deprived of its Water, and expelled in Form of a small Pellicle, which retards the further Evaporation. If you continue to inspissate by increasing the Fire, the whole Nitre turns to an unformed Mass: But, if the boiling Solution is put in a cold Place, there remains as much Nitre in the Solution, as may have been dissolved in that Degree of Cold, by a Quantity of Water equal to that which is in the Solution. The rest is separated in Form of Crystals, that is, above half of the Nitre, if the Atmosphere is very cold; and less, if it is very warm. Apply the same to Brine. But as a cold and very saturated Solution of common Salt admits but very little more Salt, if it is made warm, the small Crystals appear at the Surface, in the very Beginning of the Evapo-

ration, and are very little increased when the Brine grows cold. Now, if you suppose that Solutions of Nitre and Salt are mixt together, and consider, at the same Time, that the Salt will be better dissolved by cold Water than the Nitre, you will easily conceive, why the Crystals of the Nitre are separated, while the Salt remains in the Solution.

OF GLASS.

Our chief Design does not require that we should give in the following Processes a compleat Account of the Art of making Glass. It will not be useless, here to insert only a few Processes concerning Glasses tinged by Minerals, and to add those Things which are necessary to understand the said Processes. For one has attempted to guess from the Colours which Glasses borrow from the Minerals that are mixt with them, what Kinds of Metals they did conceal. Therefore, you will plainly see from the following Processes, whether this peculiar Kind of Trial may be done, and how far it may be carried.

PROCESS LXXVIII.

To try, how much Glass, the Caput Mortuum of Cobalt or of Bismuth, will be able to change into blue Smalt.

APPARATUS.

1. CHUSE clean fusible Sand, or Flints that are white, or at least that can be rendered so by Calcination; put what Quantity of them you please into a Crucible, and expose it to a pretty strong Fire: Pour the Mass quite red-hot into a Trough full of cold Water. By this Means, the small Stones will be split, and rendered fitter for a more easy Pulverization: Pour out the turbid Water, and grind
your

your Stones thus prepared in a very clean Iron-mortar, or upon a very hard Piece of Porphyry, to a subtile Powder.

2. Take four Parts of this Powder, as much of Pot-ash, or of some other alkaline fixt Salt well purified, and one Part of Cobalt well roasted, or of eliquated Bisinuth-Ore, both likewise comminuted, and pound them together in a Mortar, that they may be thoroughly mixt: Let them melt for a few Hours in a well tried Crucible covered with a Tile, in a most violent Fire having a Draught of Air. When the Crucible is taken out of the Fire, cool it by sprinkling it with Water, and then break it: Examine the small Bits of Glass, whether they are opaque, of a very dark blue and almost blackish Colour; and finally, whether they are ground to a finer Powder, and appear of a pleasant light blue Colour. If the Colour is too light, and the larger Bits of Glass almost transparent, you must add two or three Times more of *Caput Mortuum* of Cobalt, or of Bisinuth; subtracting something, if the Colour proves too deep.

3. If instead of the first Mixture, you use Glass pretty transparent, without any Colour, and already made of Flints and Salt, it will be the same Thing: But as this is refractory not only of its own Nature, but is also rendered such by the Cobalt, it is proper to add moreover one third Part of Pot-ash with respect to the Cobalt.

The Use and Reasons of the Process.

1. This Earth which tinges Glasses with a blue Colour, has been found only in the Cobalt of Arsenick and Bismuth, and it may be known *ex tempore*, if you but melt it with two or three Times as much Borax, on Account of the specifick blue Colour which it gives to this Salt. It is not metallick: At least, Artificers have not been able, by any Methods hitherto-known, to extract any Metal out of them; unless there remains per-

haps a little Bismuth in the *Caput Mortuum*, the Regulus of which, being collected in larger Preparations of this Smalt, is commonly poured off before it is flung into Water, lest all should fly about, with great Danger to the Operators, or the House be set on Fire. But there are Cobalts void of Bismuth: Nor is even this Colour produced by Bismuth; nay, Glasses melted with Bismuth are tinged with a peculiar purplish Colour: In short, this Colour can no Way be derived from Copper, nor produced by any Artifice whatever. But Smalt is produced better from one Species than from another; and is made of the best Kind, out of the *Caput Mortuum* of the Ore of Bismuth.

2. As for the rest, you are to observe that this blue Smalt contains a great deal of Arsenick: Because it most strongly adheres to all Salts and Earths, and emits, when melted in a violent Fire, an arsenical Fume, different from the Vapours of fixt alkaline Salt detained by a great Fire. The managing of it with Copper, and finally the Solution of this Smalt by a great Quantity of Alkali both in Fire and Water, shew this to be true.

PROCESS LXXIX.

To find out what Sort of Metal lies bidden in an Ore unknown, from the Colour it gives to Glasses

APPARATUS.

1. **R**OAST your pulverized Ore in a Fire strong enough to make it middling red-hot, in a Vessel that is covered, to keep all Filthiness from falling into it. Mix a few Grains of this Powder with one Ounce of crystalline Glass reduced to a subtile Powder; taking all imaginable Care, that nothing metallick, or of any other heterogeneous Body that tinges Glasses, may mix to it. Let them be in Fusion for some Hours, in a Fire, having a Draught
of

of Air; then, take out the Vessel; let it grow cold, and then break it. They endeavour to judge from the Colour of the small Bits of Glass, what Metal, or metallick Earth, was contained in this Ore; for Instance, from the green Colour they conclude that it contained Copper, from the greenish rusty, that Iron, from the whitish and milky, that Tin, &c.* and so on. If the Tincture is not so sensible, the Operation must be repeated with adding a greater Quantity of the Ore.

The Use and Reasons of the Process.

I. This Method of trying Ores has not yet been made use of enough, so that one may conclude any Thing certain from it. I shall boldly say, that in most Cases you cannot with any Probability conjecture what Metals lie hid in Minerals: And that there is no thinking of the Quantity of them. The following Observations render the Thing very difficult, and even makes one despair entirely, that ever the Art of making Glass, as to the tinging them with metallick Colours, will be brought to Perfection, and the Art of Assaying Metals be sufficient to that Purpose. For first, the Colours of Metals,

* Precious Stones are supposed, in their natural State, to be originally of two Classes, the Adamantine and the Crystalline; if they are found in their *Matrix's* untainted by any metalline Substance, they remain pure Diamonds of the clearest finest Water, or Crystals perfectly transparent; but if a Diamond is tinged with Lead, it appears yellow; if with Copper and Iron, it becomes green; and if with Cinnabar, it makes a most beautiful red, and then changes its Name to a Ruby, and loses of its Hardness in Proportion to the Mixture of the Metal with it. A Crystal tinged with Iron becomes a Garnet; with Copper and an Alkali, a Sapphire; with Copper and an acid, an Emerald; with Lead, a Topaz and a Jacinth; with Gold, a Chrysolite; with Copper and Iron, an Aquemarine, and so on in many Varieties (See *Woodward's Method of Fossils*, p. 23, & *Seq.*) and each of these latter may be imitated, by mixing Preparations of Metals with the finest white flint Glass, by which Method all Sorts of Gems being counterfeited, are called *Pastes*, and are used to take off Impressions of antique *Intaglia's* and *Cameo's*.

whether

whether simple or mixt in any Proportion and Manner whatsoever, whether calcined or joined to Glasses, differ very much according to the Degree and Duration of the Fire, which you have employed during the Calcination of the Metals, and the Fusion of them with Glass when they are melted; so that it is hardly credible, that the same Glass, taken out of the Fire at different Times, should appear under such a Variety of Forms; nay, that the Colours of it should vanish entirely. Secondly, there are Metals the *Calx's* of which give Glasses a light Colour, and others which being calcined make them of the deepest Dye: Whence it happens, that when such Bodies are mixt together, the Colour of the one or the other grows quite obscure, and vanishes entirely. But, there are seldom Ores, in which one single Metal lies hid alone: And there are almost always two or more of them joined in the same *Matrix*, and in a Multitude of Ways, Proportions, and Qualities. But then the Colours resulting therefrom, are of the greatest Variety distinguishable again by the Eye, but impossible to be described, and so infinitely multiplied, that the most experienced Artificer could hardly indicate the least Part of their Causes. Other Metals, on the contrary, will not manifest themselves at all by any Colour, in such a Mixture. Let there be, for Instance, Ores, in which Lead and Copper lie hid in many Proportions, the Copper, however, not being in too small a Quantity therein. Melt one Ounce of crystalline Glass with a few Grains of this Ore: The Colour will prove of a bluish green Dye, and the Lead that was hidden in that small Quantity of Ore, though it were ten Times more than the Copper, will not in the least betray its Presence by the Colour, nor will the specifick Hardness and Weight of the Glass be sensibly increased by so minute a Quantity: If you add a great deal of the Ore, the Colour will be totally obscured by the Copper. The same will, in this Case, take Place in Tin, Silver, Gold, and Antimony. Thirdly, there are other Bodies

not metallick, which not only give Glasses the deepest Colours; but also reduce the destroyed Colours which had been first produced by Metals. Such are the *Capita Mortua* of Cobalt and Bismuth, several Bodies merely terrestrial, inflammable, fuliginous, &c. From these Matters of Fact it is plain, that these Vitifications ought to be performed with the utmost Care and Circumspection, and much more neatly than all the other chemical Operations; since they may be disturbed by so many very small and hardly perceptible Causes.

2. I shall, in favour of those who love to make Experiments about Vitifications, there shew in a few Words how they can be performed conveniently with the least *Apparatus* and Expence: For which Purpose, I shall, to the best of my Power, here collect and mention what Authors have told us on this Matter, and what I myself am sure of from my own Experience. The Authors who have given us the Things chiefly appertaining to our present Purpose, are *Antonius Neri*, an *Italian Priest*, on whose Works *Dr. Merret* has given us a Commentary, and translated them from the *Italian* into *English*, and then into *Latin*. *Kunkel* has added Notes to both, more valuable than the two foregoing, as he has confirmed what was true, mended the Errors, and, what is much more, unfolded immense Difficulties by them left unravelled, the whole written in the *German Language* *.

The Furnace that is necessary for these Experiments, is represented in *Tab. VI. Fig. I, II, and III*, and described at the End of this second Part. I have at last, by much Experience, so adapted this Furnace to these Operations, that a much more violent Fire may be applied to the Vessels, and many of them be put at once into it, and the Roastings and Calcinations, here requisite very long, may be performed in

* But will soon be published in *English*, being already translated by the ingenious *Dr. Hampe*.

the same Fire. I shall then describe this Furnace, so as that it may be easily constructed by any attentive Reader: And for the clearer Understanding of this Matter, I have given the Figure of it to be seen at the End of this Book.

For the Matter of it, chuse Stones that will bear the strongest Fire. You will easily observe this, if you use a Stone for the Support of a Crucible, in which, for Instance, a strong Fusion of Copper is performed: If this Stone does not adhere to the Bottom of the Crucible when it is taken out, nor looks to be run to Glass; except perhaps it has a very thin vitreous Crust, nor contracts Chinks, and preserves its Hardness when grown cold; it is very fit for the intended Use. You may instead of Cement use a clayey * Matter, of which the same Stones, or Bricks †, and the docimastical Furnaces are made. But your Stones must be so fitly adapted to each other, that the thinnest Stratum of Lute may be sufficient to conglutinate them.

Let the Room in which it is to be constructed, have a Chimney that gives a rapid Motion and Draught to the Smoak: All the large Passages opening to the Air must be such as may be shut, and the Furnace be made near this Chimney, in such a Place, as that the Artificer may freely move round it.

The outward Figure of the Furnace may be cylindrical and arched at Top. Let the outward Diameter be twenty four, or more Inches, according to the Difference of the Stones; the Height must be forty eight Inches: The Thickness of the Wall, where it is thinnest, must be four or six Inches at least. The inward Cavity is divided into four Chambers, which are formed according to a parabolick Line. The lowermost serves for an Ash-hole, and is twelve Inches high, and its greatest Diameter at Bottom fourteen Inches. Whence the Description of the Parabola is self-evident. Let this Arch be open at Top

* Windsor Loam or Sturbridge Clay will answer this Purpose.

† Windsor Bricks.

with an Hole ten Inches wide; so that there may be left in the Back of it, a Margin two Inches broad round the Cavity of the Furnace. This Margin serves to support prismatical, quadrangular, Iron-Bars, which must be put upon the round Hole, instead of a Grate. These Iron-bars are fastened with a *Stratum* of the best Lute of the same Thickness of the Bars, at the Place where they rest upon the Margin. This Lute must be neatly smoothed, that small Vessels may be set upon it all round. Leave at the Base of the Ash-hole, a square open-Door, six Inches broad, four Inches high, with an Iron Door hung on Hinges.

The other Chamber built upon the foregoing, is a fire-Place to put in the Fuel of the Fire, and of the same Breadth and Height as the foregoing; unless the Stones it is made of are less durable in the Fire: For, in this Case, it must be a few Inches broader, and be covered over with a Crust as many Inches thick, of the best Lute that will bear the strongest Fire. Let the Top of the Arch be perforated with a round Hole six Inches in Diameter, round the Circuit of it the Arch must not be thicker than a Finger's Breadth. Let there be upon the Back of this Arch a Pavement four Inches broad, to put the Vessels upon. Make in the Circumference of this Chamber seven equidistant Doors, six of which must be four Inches broad, and as much high, and the seventh two Inches larger, all of them arched at Top. Let the Bases of them be the Height of two Inches distant from the Margin upon which the Iron-Bars are fixt, which Margin must be considered as the Pavement of this Chamber. Let the Wall at the Basis of each Door, and at the above mentioned Interval, be cut out on the Inside to one third Part of its Thickness. But, let all the Doors be of Iron, hung on Hinges, and made in the same Manner as *Part I.* § 239. N^o. 4, coated two Inches thick. When shut, they must be received into a Groove, cut on the Inside in the Wall, of the same Depth as that of the coated Door, and but a few
Lines

Lines broad: Let there be besides a small Hole at the Top of each Door, that one may conveniently look into the Furnace.

The third Chamber built over this, is perfectly like the two foregoing, except that the Arch is a few Inches lower, and there is a quadrangular Hole communicating from this Arch into the fourth Chamber, not in the Middle but towards one Side, and cut equilateral, being four Inches square.

The fourth and last Chamber is arched, equal in Breadth to the foregoing, and only eight Inches high. On the Side opposite to the Hole which from the other Chamber communicates into this, at the Height of two Inches above the Pavements, let there be a cylindrical Funnel, made of an Iron-plate, and four Inches in Diameter, which leads the Smoak, and the Flame into the Chimney of the Room. Let a Passage into this Chamber be open, through a Door six Inches wide, and as much high, just above the Pavement of the Chamber, opened in the Middle of the Circumference, between the quadrangular Hole and the Funnel. To which Aperture let an Iron-door be hung, that the Vessels may be conveniently introduced, and taken out.

Use this Furnace in the following Manner. Make a Fire in the second Chamber: And use for your Fuel Charcoal or Wood very dry, especially Beech, which must be put in through the largest Door of this Chamber. As to the Choice of the Fuel for the making of a strong Fire in general, observe what follows. If you have a Mind to urge with the strongest Fire a Body surrounded on all Sides with Fuel, you must in this Case chuse the Coals that are of a small or middling Size, nor must you put between the Grate and the Vessel which contains the Body to be changed, a Support higher than three Finger's Breadth, if the Vessel is very large; nor lower than one Finger's Breadth, if it is very small. But, if the Vessels are put at the Side, or above the Fuel, as is most commonly done in this
Furnace,

Furnace, that they may be exposed to a strong Heat, and to a very quick Flame, you are to chute larger Pieces of Wood and Charcoal. Now, if you open in the Wall of the Room, a Hole somewhat larger or at least equal to that which is at the Bottom of the Ash-hole, and make a Pipe or Trunk of Iron-Plates leading from the former into the latter, and on the other Hand shutting the Room very close all round, that the Air may not rush in too freely; then, the Blast of Air that passes through this Trunk, is the stronger, as the Chimney of the Room grows the warmer: Whence the greatest Degree of Fire produced by a Draught of Air, is at last obtained. But the Fire will be of the utmost Strength at the small Doors of the second Chamber, so that a few Ounces of Copper being flung without any Addition into a Crucible that is red-hot there, will melt in a Minute, being agitated by a Fire greater than is necessary for the pouring of Copper into a Mould, to represent any certain Figure. The Vessels are put in through the small Doors, and are put upon the Margin, whereon the Iron-Bars which form the Grate, are placed. You may place as many Vessels round the Circumference of the Chamber as there are Doors in it. The Vessels which are put in, before the Furnace is perfectly warm, may be put upon a low Support, made of a Stone one Inch thick, and not ealy to be vitrified. You may see and try the Matter in the Vessels, through the small Hole made in each of the Doors that are hung on Hinges. In the third Chamber, you may, on Account of its Pavement's being much broader, put a double Row of Vessels therein, that is, twelve in Number, or more, if they are of a middling Size. The Fire is milder in this Chamber than in the foregoing, *viz.* a middling melting Fire. Finally, the Fire is much more gentle in the fourth and uppermost Chamber, and is of very great Use for Calcinations and Roastings, to be made in a middling Fire: But then, indeed, the Vessels do but grow red-hot there. If you have a
Mind

Mind to put your Vessels in the Furnace already hot; they must be previously made very warm; then, they are able to bear the Heat in the fourth Chamber, out of which they may at last be put into the Third or Second, when they are already red-hot.

You must, before this Furnace is constructed, make an *Apparatus* for several Operations: And thus you will perform a great many Experiments, with very little Trouble and Loss of Time: So that I can assure my Readers, that none have been more agreeable to me than those I have made in this Furnace, though they are extremely tiresome by any other Method, on Account of the strongest Fire which must be continued so very long. I do not indeed exaggerate, in saying that all the Operations are twice as easy, when you know how to make a right Use of this Furnace.

For want of it, I formerly used with some Success the Athanor described (*Part I. Plat. IV. Fig. 1.*) by applying to the Ash-hole of it a Wind-pipe, like that applied to the foregoing: I put the Vessels that were set upon low Supports, into the Chamber next to the Tower: I took quite away the Iron-Lamina which intercepted the Passage of the Fire: I stoppt the fore part of the Chamber, with a Wall made of Cement and Brick, in which I left two small Doors, to introduce and take out the Vessels, which Doors might be shut with Stopples. I placed the Vessels to which the strongest Fire was to be applied, next to the Hole which conveyed the Fire from the Fire-place that was in the Tower, into this Chamber: And those which required a more gentle Fire, I placed in the Middle, and over-against the foregoing: But, as the Stones were not of the best Kind, and the Fire, continued for two Days together, was most violent, the Furnace was almost destroyed, and the Supports of the Vessels almost immersed in the vitrified Stones; though no Glafs had run out of the Vessels: Which must be prevented with all imaginable Care; for, if it
happens

happens so a Number of Times, your Furnace will be totally destroyed.

They use for their Vessels in Part common Crucibles, and melting Dishes, which are put into the Furnace either open, or covered with Tiles. But, if you have a Mind often to try and stir up the Matter within them, and are at the same Time to avoid the falling of Ashes, which fly about, into the Vessels, you must make an Hole in the upper Part of the Vessel on one Side, and then cover it with a Tile to be fastened with Lute. You may also make on Purpose small cylindrical Vessels *, shut close at Top, having a like Aperture. If they are put into the Furnace, their Opening must look towards the Door. If you use triangular Vessels, the Angle must look towards the Centre, and the opposite Side towards the Door: For, if you neglect this, the Vessels will easily split, as they are put in. Therefore, we will omit all the Methods of making figured Glasses; only the Compositions of them.

We have already given a general Definition of Glasses (*Part I. § 8. Schol. 451—2.*) They are in part *the simple ones*, which may again be subdivided, 1. Into merely *terrestrial*, to which Class all the vitrescent Stones do belong, and it is all one whether they are crude or already melted: For, the crude vitrescent Stones have all the Characteristicks of Glass. 2. Into *metallick*, that is, the Metals and Semi-metals; all of which, except Gold, Silver, Mercury, and Arsenick, turn to *Calxes* properly so called, by Means of a gentle Roasting, and into Glass at last, by applying a stronger Fire to them. They are also in part *compounded ones*. Now they are composed either of the simple Ones just mentioned, or alkaline and neutral fixt Salts are added to them, of which we are going to treat in a more special Manner.

* Of Sturbridge Clay.

P R O C E S S LXXX.

The making of common Glass, and the Extraction of Salts out of Ashes, for the preparing of it.

A P P A R A T U S.

I. **A**LKALINE fixt Salts produced out of burnt Vegetables, melted together with vitrescent Earths, turns to what is called common Glass. The alkaline Salt, with its *Matrix* Earth, that is, Salt-ashes remaining after the burning certain Vegetables, being melted in a strong Fire, turn to Glass, with which you may likewise melt a Quantity of Sand, or of pulverized Flints, which may be in greater Proportion, as the Ashes were more Salt. This Glass is the hardest of all, more refractory in the Fire than the other common Glasses, perfectly resisting the Air and Water, and all liquid *Menstrua* that are known: On which Account it is not to be esteemed less than the finest crystalline Glass, because of its vast Usefulness. Its Colour is commonly of a dark green Dye, sometimes quite opaque and black. The Reason of this incomparable Durableness consists in the perfect Mixture of the Salt and the Earth, as likewise in the great Quantity of the latter, whereby it surpasses the former much more than in any other Glass. Salt, for Instance, is most equally and minutely divided through the Ashes; whence its dissolving Virtue is so much increased, that this little Quantity of Salt is able to bring so great a Quantity of a very refractory Earth, to a State of Fusion. The Ashes being deprived of all Salt, by repeated Roastings and Edulcorations, and rendered so pure as to be used for the making of Coppels, if you mix them again with their proper Salt, and put them in the strongest Fire fit for melting Glass, it will never be

be possible to bring them to such a Degree of Fusion, as that tractable Glass to be figured by blowing, may be made out of them; though this Salt lying still hidden in its own Earth of the same Kind, was able to dissolve not only the said Earth, but also one third Part, and even more, of the Sand which had been added over and above.

2. To make clear common Glass more transparent, you must extract the Salt out of the saline Ashes of any Sorts of Vegetables. But you must chuse Vegetables that have been gathered in their perfect Growth, not exposed long to the Injuries of the Air, nor very old neither: For, the Rains and the Air itself at last wash off and consume that, out of which fixt alkaline Salt is afterwards to be produced by Fire. Nor can you even produce out of all Vegetables, a Quantity of fixt Alkali that will repay your Charges and Troubles: You must consult the Experiments of Chemists upon this Matter. All these Salts are perfectly the same, after they have been duly purified, as is observed by *Kunkel*: For this Reason, it is altogether needless, to prepare, for the composing of Glasses, so many Salts, so difficult to be got, and on this Account so very dear: Since a single Kind of Salt extracted out of the vilest Vegetable, is as good and sufficient for your Purpose, as all the others together *. The extraction of Salt out of the Ashes, and the Purifying of it is performed, 1. By Solution in about three Times as much warm Water, with which the Ashes must boil for a while, and be stirred now and then with a wooden Stick. 2. By straining through a filtrating Paper, or through a Linnen-bag: Which must be repeated by pouring back the Water over and over again, till the Lye passes through quite clear. 3. By Evaporation, which is performed in an Iron-pot well cleaned of all Rust. During the Evaporation, you are to avoid that any Ashes should

* The Sea weeds, especially that Sort called *Kali* or Glasswort, abounds most with this Sort of Salt.

fall into it, and you must make under it a Fire that makes it boil gently : But you must first have a sufficient Quantity of Lye ready, that you may be able to fill the Pot eight or six Times at least. Nor must you pour more at once than is necessary that the Pot may be half-full, lest the Salt should form a Crust in the upper Part of the Pot, that would be difficult to separate. As much Water as is dissipated by Evaporation, so much fresh Lye must be now and then poured into the Pot. When the small Clots of Salt begin to thicken, and to appear in the Lye, and a small saline Crust covers the Surface of it, diminish the Fire, and with a Wooden-scraper, or an Iron-ladle, stir it circularly, till there remains a dry pulverulent Salt. When you see this, you may bake it quite dry, without any further stirring. If you neglect this stirring, and the Diminution of the Fire, a very hard Crust of Salt will apply itself to the Pot, which cannot be separated but with a Mallet and a Chizzle and not without a Mixture of several Particles of Iron, by which violent Percussion, the Pot which is of melted Iron, and brittle, is frequently split. Mix two Parts of this Salt, which will be brown, or somewhat yellow, with three Parts of pulverized Flints, or of Sand; melt them together in a great Fire, in which the Mixture being left for several Hours, will turn to a Glass finer than the foregoing, but less durable; because it contains much more Salt, and the Mixture is not so perfect. But we cannot determine a constant Proportion of the Flints or Sand, and the Salt, because of the Variety of the Stones. For some Flints are more fusible than some others: It is the same with the different Kinds of Sand; which must be evinced by Experiments. Salt produced in an Earthen-pan, put immediately into the uppermost Chamber of the Furnace, or in its Pavement, and calcined with only a gentle Fire, lest it should melt, and freed of a great Quantity of Fat which it still contains, will become perfectly white: Or, if you have used too strong and long-lasting

ing a Fire, it will assume a light bluish and greenish Dye, with which you will afterwards make a Glass more beautiful, more transparent, and more free from all Colours than the foregoing. But a strong Fire continued long, very much promotes this Beauty and Duration. A more perfect Mixture is obtained, and the superfluous Salt dissipated by the same; because the fixt Alkali vanishes in form of a white Smoak: But, it is impossible to dissipate it intirely: For, part of it is most intimately joined by the Flints. Thence now it is plain, why Glasses of different Degrees of Beauty and Durableness, are produced out of one and the same Mixture, it proceeding from the different Degrees of the Strength and Duration of the Fire. For Glasses taken suddenly out of the Fire, grow obscure of themselves in the Air, and sometimes fall asunder into Powder, though the just Proportion of the Stones and Salt has otherwise been observed: Which will also happen the sooner, if there is more Salt in the Mixture than is requisite.

P R O C E S S LXXXI.

The Preparation of the Salts, for making of crystalline Glass.

A P P A R A T U S.

IF you are willing to have the finest crystalline Glasses *, you must purify your Salt several Times by Solution and Crystallization. For the coarser Earth is not sufficiently separated by the first Solution; though you should strain your Lye through the densest Filters. Therefore, you must dissolve your Salt (*Proc. LXXX.*) a second Time, and purify the Lye by Filtration; then inspissate it in the same Manner in the cleanest Iron-pot, till the Lye be at last so thick, as that a thin saline Crust begins

* Commonly called white flint Glass.

to appear at Top, and small saline Masses at the Border and the Bottom of the Pot: Then let the Lye grow cold, and rest for a few Hours; which done, you may take out a great Quantity of the purest Salt, with an Iron-ladle: Continue to inspissate the Residue of the Lye in the same Manner, till no more Salt can be separated in this Manner, and the remaining Lye turns to a muddy Liquor, which serves to make the coarser Kinds of Glasse: When the first Salt is perfectly clean, dry it. If you purify your Salt thus once more, it will be fit for making the finest Glasses. Salt extracted out of Ashes, and then purified, and calcined, may at once be rendered as pure as it can ever be by any Art, if by exposing it to a pretty moist Air, you let it run to Water and crystallize the *Oleum per Deliquium* of it, in the Manner aforesaid. But it is not necessary to bestow so much Labour for small Experiments; if you are willing to have the finest crystalline Glasses, Pot-ashes are to be bought very cheap every where, which have already been rendered sufficiently acrid, by being burnt in the Fire, and become most fit for this Purpose, when they have been purified from the neutral Salt (which is most difficultly dissolved in Water) and from the coarse Earth wherewith they are full, by a Solution in four Times the Quantity of cold Water, or much better by decanting, and then strained, and at last crystallized. There are also some other Salts which enter into the Composition of Glasses, especially Nitre, which, if not pure, must be purified by Solution, and by pouring gently upon it a few Drops of Oil of Tartar *per Deliquium*, and finally by Crystallization. It is the same of Borax, which is prepared by Vitrifications by a gentle burning, whereby a small Quantity of it swells into a prodigious, most light, and spongy Mass, of a very white Colour: However, it is proper to avoid the melting of it. If you neglect this Preparation, the Mixture to which it is added, will boil over the Vessels though ever so large.

PROCESS LXXXII.

*The chusing and preparing of Flints for the making of
crystalline Glafs.*

APPARATUS.

PULVERIZE Sand and soft Flints in an Iron-Mortar, not rusty: And if it were rusty, you must first grind in it common Sand, which will make it perfectly clean. This must always be done, when you have a Mind to make crystalline Glafs clear from all Colour: But, it is not necessary to do it, when you are willing afterwards to tincture your Glasses with Iron. For the making of the hardest Glasses, chuse the hardest Flints, such as are the black Flints that serve for Gun-flints, and some very hard Quartzs that will resist any File. All those which either are white, or grow such when calcined in the Fire, are of this Kind. They must first be cleansed of the chalky Crust commonly adhering to them, then calcined in a strong Fire, and thrown as yet red-hot into cold Water. Thus they will be softened, and become the whiter, as they were blacker before. Wash off the Ashes that may happen to adhere to them, and at last pulverize them in a Mortar, that they may pass through a very fine Sieve. When this Powder is most subtile, if you have not a Mind to tinge the Glafs to be made of it with the *Crocus's* of Iron, pour upon it weak *Aqua Fortis*, or its Phlegm. Stir it first several Times, and let it rest for one Night, then decant it, and again wash it several Times with pure warm Water: You will thus have Sand perfectly subtile, as good to make the hardest crystalline Glasses, as if you used Rock-crystal itself, according to the Observations of *Kunkel*.

PROCESS LXXXIII.

The Composition of crystalline Glass.

APPARATUS.

WE have already observed, that it was impossible to assign a constant Proportion in the composing of Glasses, on Account of the different Degrees of Fusibleness in the Flints; therefore, we shall here insert a few Prescriptions, by way only of Specimen.

Take of prepared Flints pp. VIII. of the purest alkaline fixt Salt pp. V.

Otherwise: Take of prepared Flints pp. III. of the purest alkaline Salt, and of burnt Borace p. I. each.

Otherwise: Take of prepared Flints pp. III. of the purest Nitre pp. II. of the purest alkaline Salt, and of burnt Borax p. $\frac{1}{2}$ each. Of white crystalline Arsenick p. $\frac{1}{8}$.

If you add Arsenick, it must first be intimately mixt with the Salts, especially Nitre, and this Mixture be joined with the Flints. The Effect of Arsenick here, is, that the Salts dissolve the Flints with greater Efficacy: And it does not entirely evaporate, as has been already observed, but being in great Part fixt by the Glass it sustains the most violent Fire. Whether it also takes away the greenish and bluish Colour of Glasses, if such a one is produced by the Impurity of the Flints or Salts proceeding from a Mixture of metallick Particles, and in what Manner it does it, if this be the Case, must be evinced by a further Inquiry.

If you have a Mind to melt these Mixtures, chuse a very clean Vessel, shut close at Top, that no Filthiness may fall into it, having a small Hole on the Side, that the Mass within may be examined. But, before the Matter is put into the Vessel, this must

first

first be baked, and glazed with a vitreous Crust of Litharge. This is done by putting Powder of Litharge into the small Vessel still moist before the baking of it, shaking it in the Vessel and exposing it to a moderate Fire, after having thrown out what is superfluous: Which may be done in the third Chamber of the Furnace. Thus you will preserve your Glass from being tainted by small Stones and Dust loosely adhering to these Vessels, which are then fastened by the Litharge. Every Thing being thus prepared, fill two Thirds of the Vessel with one Composition, and before you expose it to the strongest Fire, roast it for an Hour in the fourth Chamber, then put it into the Third or Second, that it may melt thoroughly, there it must sustain a long Fire, till it is sufficiently fine, and free from Bubbles: Which requires the Space of several Hours. To try this, touch the Surface of the melted Glass with a new Tobacco-pipe, to which a small Portion of Glass will adhere when you take it out. Take Care, in making this Trial not to move your Glass: For as often as you do this, it contracts new Bubbles; which cannot easily go away in so tenacious a Mass. If these Glasses are left long enough in the strongest Fire, they are harder and more transparent than any. If you will have large Bits of it, it must be most slowly cooled in the fourth Chamber, and the Vessel be broken, or be ground away upon a grinding Stone, in the Place where it is contiguous to the Glass.

P R O C E S S LXXXIV.

To tinge Glasses by Metals, and other Bodies.

A P P A R A T U S.

WE have already given Specimens about these Glasses (*Proc. LXXIX.*) where we laid down the general Observations to be made on this Matter: We must now treat of them in a more special Manner. The Preparation of the *Calx* of Metals where-
with

with Glasses are tinged, require a Variety of Menstrua, according to the Variety of the Metals.

The Calcination of Iron and Copper is performed almost by the same Things, the principal of which are: 1. Fire alone, which destroys the Metals called imperfect, and even Iron itself very easily without melting, and Copper more easily still: This is done in a short Time, if you reduce those Metals to thin Plates, or to Filings, and put them in a Vessel covered with a Tile, into the third Chamber, where they are left, till they become perfectly triturable. When triturated, let them be calcined once or twice over for half a Day or more, that all the small Masses which possibly have preserved their metallick State, may be burnt. Let the Fire never be so strong, as that the *Calx* may have any Disposition to a State of Fusion. 2. Let the pulverized Sulphur mixt with Iron-filings, be exposed for a few Hours to a strong Fire, in a covered Crucible, in the third Chamber. Let the Filings be corroded, that they may become triturable, and the triturated *Calx* be roasted for one or two Days in the fourth Chamber. It will thus turn to *Colcothar* of a dark red Colour, fit to tinge Glasses. This Action of Sulphur is still quicker upon Copper than upon Iron: For pretty thick Plates of the former stratified with pulverized Sulphur in a close Crucible, being exposed to a middling Fire in the third Chamber, are penetrated in a few Hours, and rendered brittle, much thicker, and of a dark Colour; and when pulverized afterwards, put into the fourth Chamber in an open Vessel, they are roasted for a few Hours, that the remaining Sulphur may be dissipated. Thus you will have *Calx* of Copper prepared with Sulphur. 3. Oil of Vitriol diluted with Water, quickly dissolves Iron, and turns to Vitriol together with it: A small Quantity of Copper is more difficultly dissolved by it (See *Proc.* LXXIII). The Crystals of Vitriol made by Evaporation, being dried over a warm Oven, fall into Powder, which must again be roasted in the fourth Chamber, edul-

corated with warm Water, dried, and kept such for Use. 4. If you sprinkle Filings of Iron or of Copper, several Times, with distilled Vinegar, and dry them again over a warm Oven; they are both corroded, and the former turns to a triturable dark ash-coloured Powder, and the latter into a green Rust.

Brass is calcined by Fire alone, but being much more constant when made red-hot, than pure Copper (*Proc. LXVI*), you must calcine thin Plates of it in a strong Fire, in the third Chamber; taking Care, mean while, that they do not melt: Because it, on the contrary, melts much more quickly than pure Copper. This *Calx* must be roasted again several Times, in a milder but long-lasting Fire.

Lead is calcined, 1. without Addition, if you melt it in a large Iron-ladle: It presently contracts a small Skin at the Surface, which must be taken off and thrown away with an Iron-scraper: For Copper, if there is any in the Lead, likewise contains in it the Filthiness which adheres to Lead: Another such Pellicle will soon be produced: Which must be taken off, and kept: Continue thus to collect the Pellicles produced in this Manner, till you have gathered a sufficient Quantity: Let them be extended wide in the fourth Chamber, and roasted in a gentle Fire, stirring them now and then with a small Hook, till they become perfectly triturable. 2. Lead is, by the Vapour of Vinegar, corroded to a white *Calx*, which being pulverized under the Name of Ceruse, is sold very cheap in all Perfumers-shops, but proves seldom genuine, and is often mixt with Chalk, Parget, and other Things: Whence the Glass-makers who use such Ceruse to make Glass of Lead, lose both their Labour and Materials. If you are willing to prepare the best Ceruse of this Kind with Vinegar, distil Vinegar of Wine, out of a Cucurbite through an Alimbeck full of thin Plates of Lead, and so disposed, that the small Drops which apply themselves to them, may neither fall into the Cucurbite, nor
run

run down again, but be all collected in the Channel of the Alimbeck, and thence run down through its Neck into the Recipient applied to it. Let the Distillation be performed in a gentle Fire for a few Days: The Vinegar saturated with Lead and dulcified, will be collected in the Recipient. Being inspissated according to Art it forms a Heap of Crystals called *Saccharum Saturni*, *Sugar of Lead*: These being calcined in a gentle Fire, fall into a white Powder, which is very useful for Glasses. *Calx* of Lead made red in an open reverberatory Fire, and called red-Lead, or the Litharge commonly sold, may be substituted for the foregoing. But, as the latter in particular, commonly leaves the *Regulus* of Lead at the Bottom of the Vessel; it must be melted, before it is added to the Mixture for the making of Glass, and then poured into the melting Cone, and the precipitated *Regulus* of Lead must be separated, or the Mixture prepared for Glass be poured into Water, if it has been only a Quarter of an Hour in Fusion; and the Lead be thus separated from the pulverized Glass. Therefore, it is also proper, to mix with those Glasses to which Litharge or any other *Calx* of Lead is added, a Portion of Nitre, which destroys the Lead, and vitrifies it soon. For Litharge consists of very subtil Scales, and of small Masses of Lead outwardly vitrified.

Tin is still more easily calcined than Lead by the first Method, and with a stronger Fire; otherwise, it is sooner prepared by the following Method in particular. When your Tin has been melted in a Crucible by a gentle Fire, add to it half as much Lead: This done, increase the Fire by degrees. So soon as it begins to grow red, the Tin is rejected out of the Mixture, in form of a *Calx* of different Colours. Continue the same Degree of Fire, till this *Calx* smoaks no longer, but sparkles: Then take it away with an Iron-Ladle. The like will be produced again several Times. When it is collected, burn it quite in the fourth

Fourth Chamber of the Furnace: But, it will not be altogether free from Lead.

The *Calx's* of Gold and Silver are prepared by Solution in their proper acid *Menstrua*; from which they are separated by extraction of the Spirits, or by precipitation with other Metals or Salts. Mean while, be aware of fulminating Gold. *Calx* of Gold precipitated out of *Aqua Regis* by Tin, is called *Calx Cassii*. Mercury itself being corroded by *Aqua Fortis* and Oil of Vitriol, is rendered more fixt, and when inspissated, it is sometimes added by Artificers, to Compositions of *Calxs* for tinging of Glasses. Semi-metals are calcined by themselves, which is easily done chiefly with *Regulus* of Antimony, or dissolved by Acids, and precipitated several Ways: Nay, when prepared with Nitre by Detonation, they may enter into the Composition of Glasses.

Having prepared these *Calxs*, you will be able to tinge Glasses in a Multitude of Manners; especially if they are at the same Time accompanied with some other Bodies.

Observe in general. 1. You must put your Mixture either in a new Vessel, or at least in a Vessel in which Glass has been in the same Manner coloured, worked, melted, and taken out. 2. The thicker Bits of Glass require less of the tingent *Calxs*, and the thinner Ones require more. 3. Use a Fire of such a Strength, as that a warm Tobacco-pipe being introduced into it, there may indeed adhere to it a pretty thick Crust, but not a large Knob of Glass: Nor must the Mixture be put at once into the Vessels; but when part of it is thoroughly melted, the rest may be put gradually into the Vessel with a small Iron-Ladle; For some Mixtures are very apt to foam: Of which we shall soon give Examples.

1. The green Colour is made of two Ounces of the Mixture for crystalline Glass, to which you are to mix about ten Grains of any Copper whatsoever, or of Brass: If you add to the *Calx* of Copper a few Grains of *Crocus* of Iron, you will have the finest Glass

Glass of a yellowish green-Colour. Thence, you will be able, by changing the Proportion of these two Calxs, to vary this Colour in an infinite Number of Manners.

2. Glasses are tinged with blue by Smalt, by Zaffre, or by Cobalt itself, previously roasted, by mixing three or four Grains of it, with two Ounces of Glass.

3. Your Glass is brown or black, if you mix with it a great Quantity of Cobalt or of Zaffre, for Instance, one Drachm. The *Croci* of Iron, and all its Ores, have the same Effect, if you melt them together in a good Quantity with Glasses. Nevertheless, there is a Variety in this brown Colour: Especially, if they are finely divided: For, then, the blue Colour of the Smalt, and the rusty Colour of the Iron, may again be distinguished.

4. You give Glasses a golden Colour, by adding to the Dose of the above-mentioned Mixture, twelve Grains of roasted Manganese, a Drachm and a half of Tartar, and six Grains of Charcoal-dust, or of Soot.

5. White, milk-coloured, opaque Glasses are prepared with Tin, by adding to your Mixture for Glass one fifth Part of Calx of Tin, to which the same Quantity of Calx of Lead must be added for a more easy Fusion, with one Grain of roasted Manganese.

6. If you melt with Flints alone, the double or treble Quantity of Calx of Lead, you will make a most beautiful Glass, of a yellow Colour with a slight greenish Cast, more fusible than the foregoing, that will soon reject its Bubbles, and casts up all the small Stones: You may also add Calx of Lead to the foregoing Mixtures. Such Glass will have the foregoing Colours in a very elegant Manner. Calx of Tin added in an equal, or a double Quantity, renders them of a milk Colour, and they may be most finely tinged, if you add moreover *Calx's* of other Metals. Such opaque and most fusible Glasses, made of Calx of Lead, of the Mixture for crystalline Glasses, and of Calx of Tin most finely mixt together, and tinged together by *Calx's* of other Metals, are called *Encausta* (Enamells.)

(Enamells.) *Amausa*, or Smalts. You may read several Things concerning these Matters, in the above-mentioned Authors.

P R O C E S S LXXXV.

Of hydrostatical and statical Examinations of Metals and Minerals.

A P P A R A T U S.

THIS, as well as the foregoing Processes, concerning Glasses, strictly speaking, do not, indeed, belong to the Art of Assaying. This Examination is performed by several *Apparatus's*, which you will find described in the hydrostatical Writers, among which you may chuse that, which, from Use and Comparifon, you will judge to be most convenient *. Make the following Observations in general.

1. Have at hand Water distilled in a Glass-veffel on a gentle Fire, that may sustain a Solution of Silver or of Lead, without being turbid: For, fountain, river, and rain-Waters, are too different.

2. Let the warmth of the Water and of the Body to be weighed, be fixt: For, it may occasion a very great Difference: Which appears presently, if you weigh in the same Water made warm, the same Body that has been already weighed. For, it will appear specifically heavier: Therefore, you must be provided with a Thermometer. But, you must chuse a Degree not exceeding much the greatest Summer-heat, for Instance 90, according to *Fahrenheit's* Thermometer. You must warm to the same Degree not only the Water, but also the Body to be weighed; which may be very well done in a *Balneo Marie*.

* Particularly the *Medicina Hydrostatica*; or Hydrostaticks applied to the *Materia Medica*, to which is subjoined a previous hydrostatical Way of estimating Ores, by the Honourable *Robert Boyle*, Esq; F. R. S. Lond. 1690. in 8vo.

3. You must first weigh the Bodies in the Air, in the most exact Manner.

4. Porous, sinking Bodies, which absorbe Water; must previously be moistened in a shallow Vessel, full of very clean Water, to expel, as much as possible, the Air out of the Interstices. For, it renders Bodies specifically lighter; but, the Water that fills the Interstices of the Body to be weighed, is indifferent with regard to the Water that surrounds the Body. But, when Bodies are moistened, they must not be immersed in the same Manner, but they must be contiguous at Top to the Air. For, by that Means, the Air inherent in the Interstices of this Body, will retire quicker, and more compleatly.

5. And as some Bodies do in a Manner reject Water, and small aerian Bubbles, that render Bodies lighter, are produced at the Surface of almost all solid Bodies, while they are immersed in Water, especially warm Water; they must be moistened as soon as possibly you can.

6. Therefore, you must as much as possible, give the Bodies to be weighed a smooth and neat Outside: For Instance, Metals reduced to a globular Form, may very easily be weighed by this Method.

7. Bodies full of Hollows, and concealing Air within themselves, must be reduced to a Powder, which must be soaked in Water for a good while, and now and then stirred before it is weighed.

8. Salts must be weighed either in Alcohol (and they must all of them have the above-mentioned Degree of Heat) or, if they are dissolved in Alcohol; or, if you have none at Hand, you must make a Brine thoroughly saturated with the said Salts, with an undetermined Degree of Warmth, and compare the specifick Weight of it, by Means of a solid Body, for Instance of Glass, immersed in it, and afterwards immersed in Water: Which Weight must be compared with that of the Water.

The other *Encheireses* depend upon the Quality of the Instruments employed, and upon your own Practice.

9. Metals are more exactly weighed statically, if you weigh first a certain Mass of the same Metal rendered perfectly pure: Which is very well done, by drawing it into a slender cylindrical Wire, and by cutting out of it a Cylinder of a certain Length, which must be weighed in a docimastical Balance. Thus you may compare all malleable Metals drawn to Wire. You will be able to conclude from an hydrostatical and a statical Examination, the Purity chiefly of Gold, as being the heaviest, and of Tin, as being the lightest of all Metals.

EXPLANATION

OF THE

FIGURES.

PLATE I.

FIG. I. A Pestle, to stamp the Coppels with. It is called in German *Munch*.

a. b. Its wooden Handle, which is fastened into the hollow Brass Cylinder in the lower Part of it.

c. d. e. f. g. The brass Part of the Pestle which is pressed down into the Ring FIG. II. filled with Ashes, to make the Cavity and Upper-border of the Coppel (§ 177.)

e. Is a spherical Segment very well polished, which corresponds to the Cavity of the Coppel.

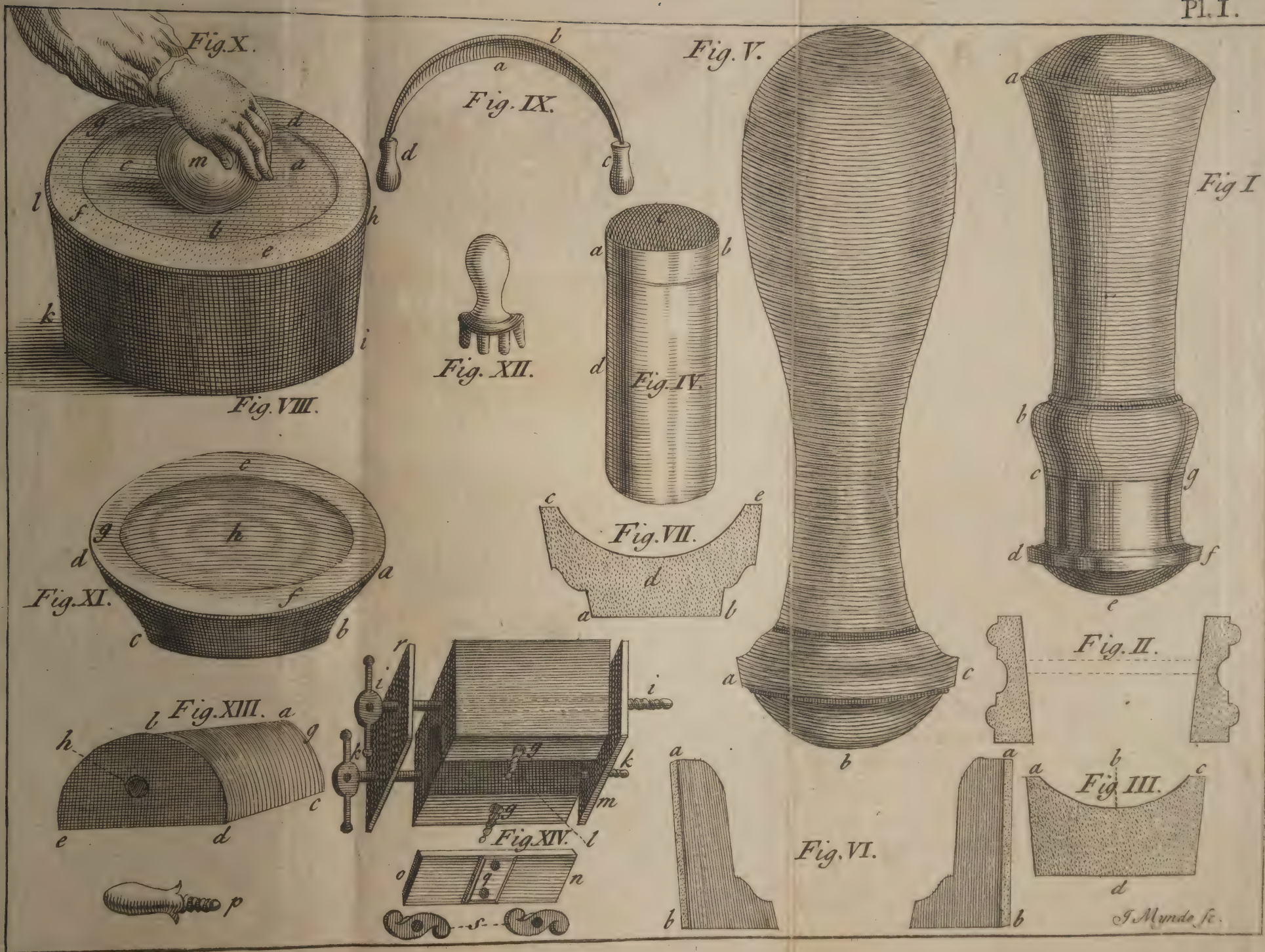
d. f. Is a projecting Border, which forms that of the Coppel.

c. g. Is the hollow brass Cylinder, into which the Handle a. b. is received.

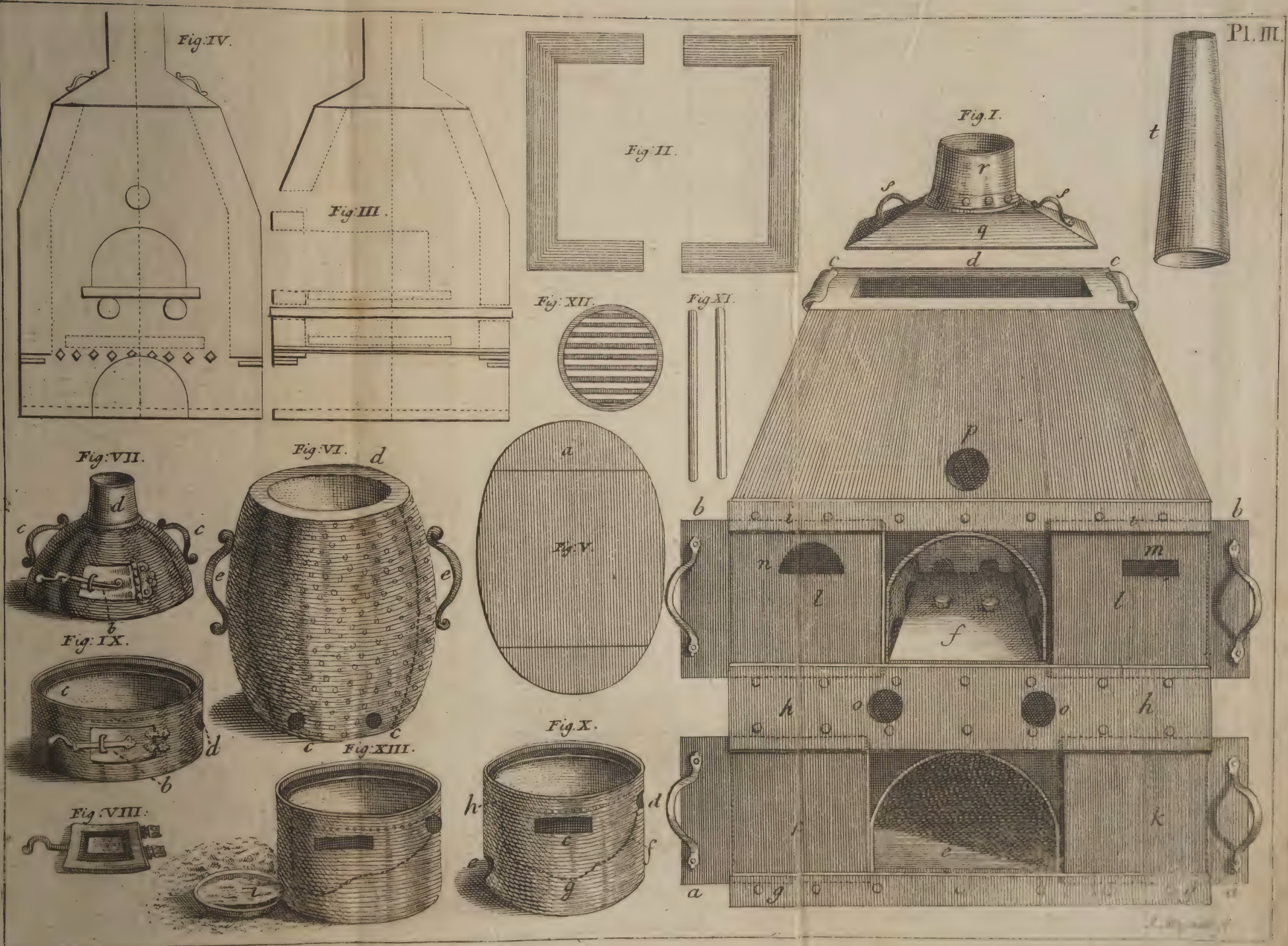
FIG. II. A brass-Ring, called in German *Bonne*, drawn according to the perpendicular Section, representing a truncated Cone, open at Top and at Bottom, which is filled with the Ashes to be pressed down with the Pestle FIG. I. The pricked Lines mark how deep the Pestle must be thrust, before its Border d. f. reaches the Sides of the Ring.

It is proper to have ready at Hand three or four such Rings of different Sizes, with Pestles corresponding to them. The least of them must form a Coppel, of $\frac{3}{4}$ of an Inch; the largest of them must form a Coppel two Inches, from out to out.

FIG.







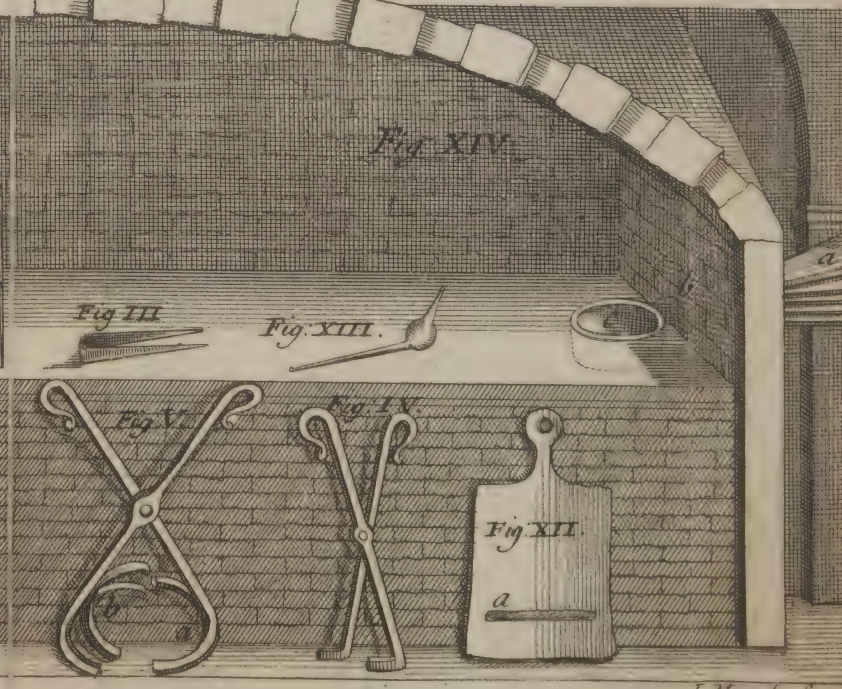
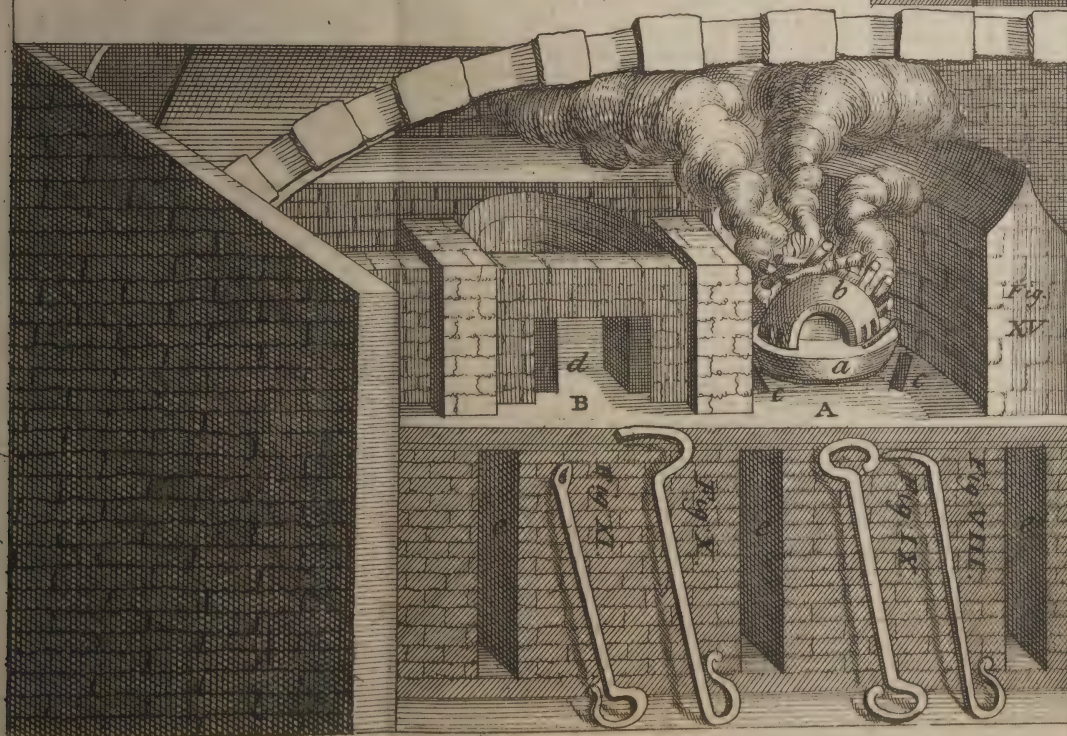
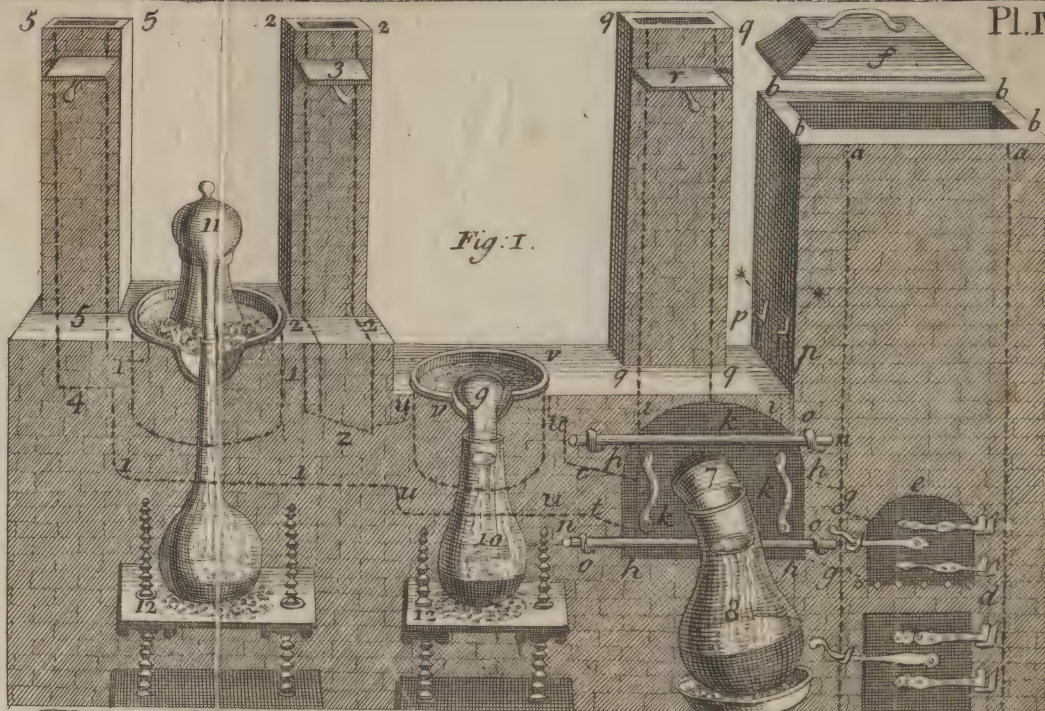
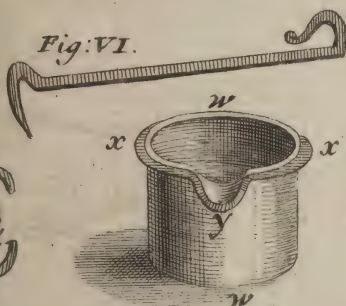
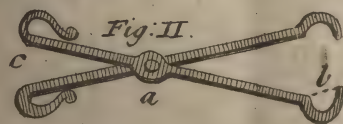
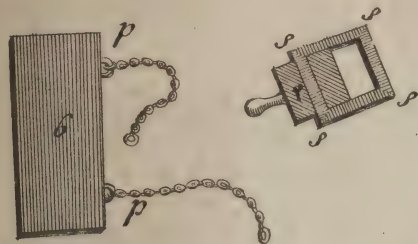
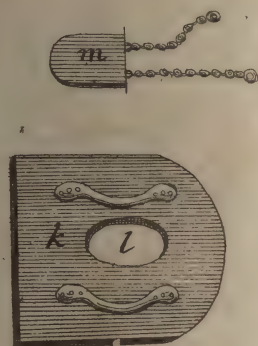




Fig. X.

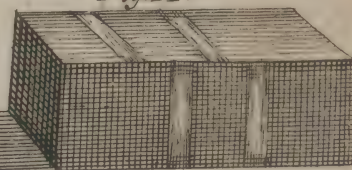


Fig. IV.

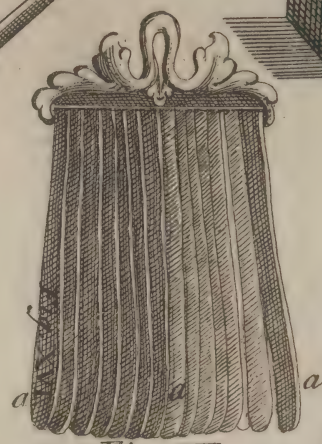


Fig. IX.



Fig. V.



Fig. I.

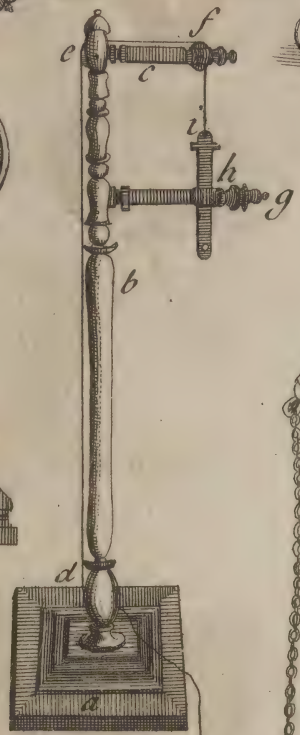


Fig. VI.

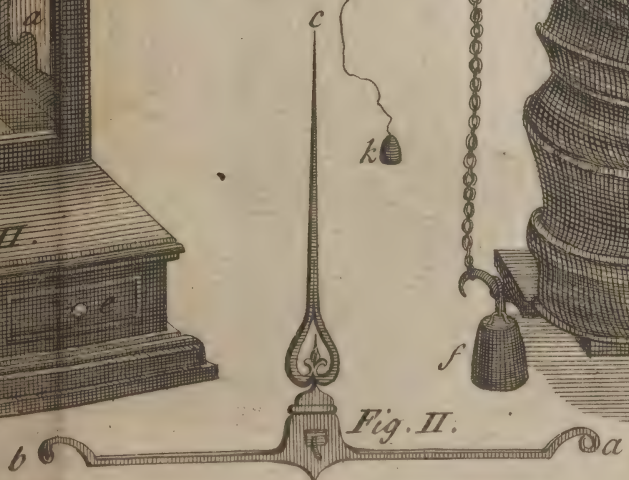


Fig. II.

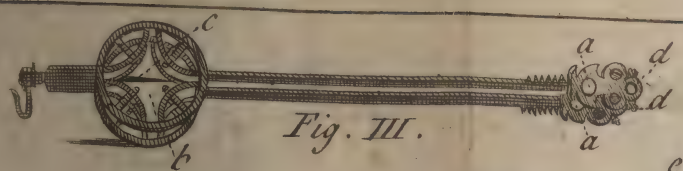


Fig. III.

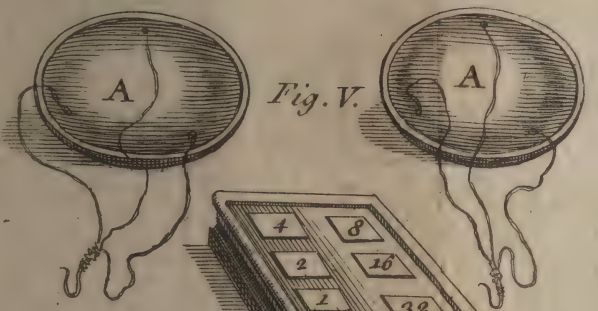


Fig. V.

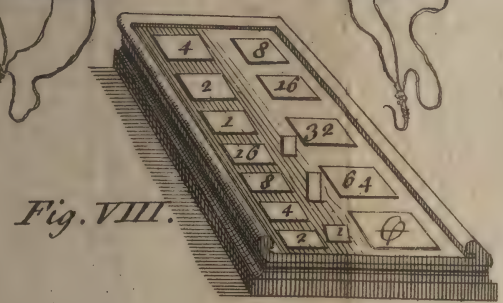


Fig. VIII.

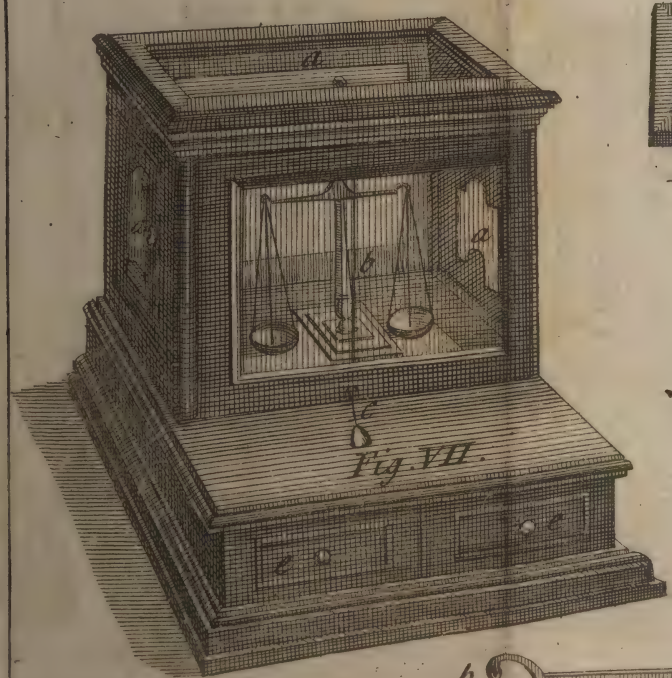


Fig. VII.



Fig. II.

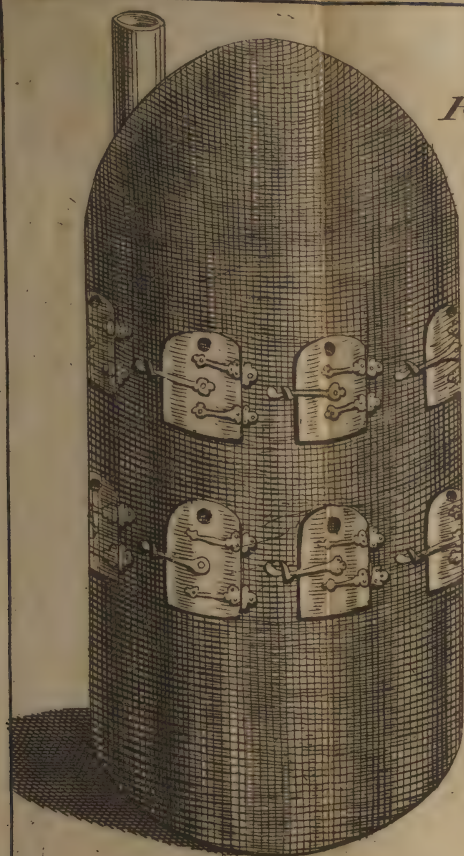


Fig. I.

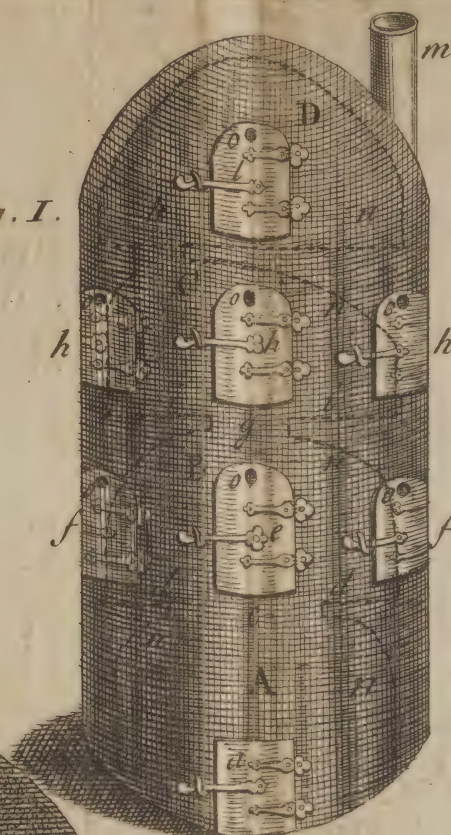


Fig. V.

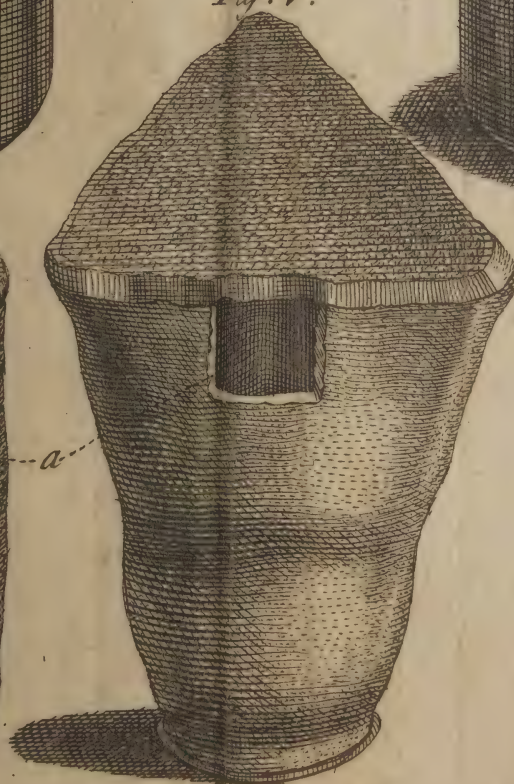


Fig. IV.

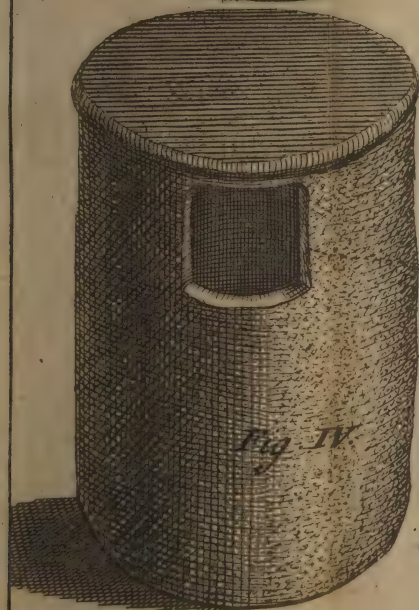
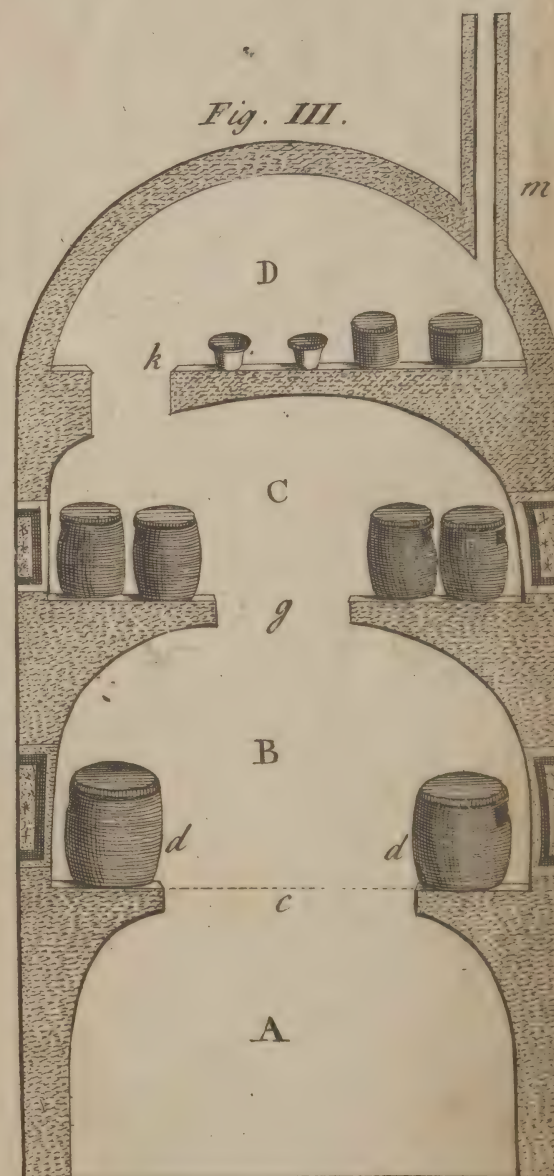


Fig. III.



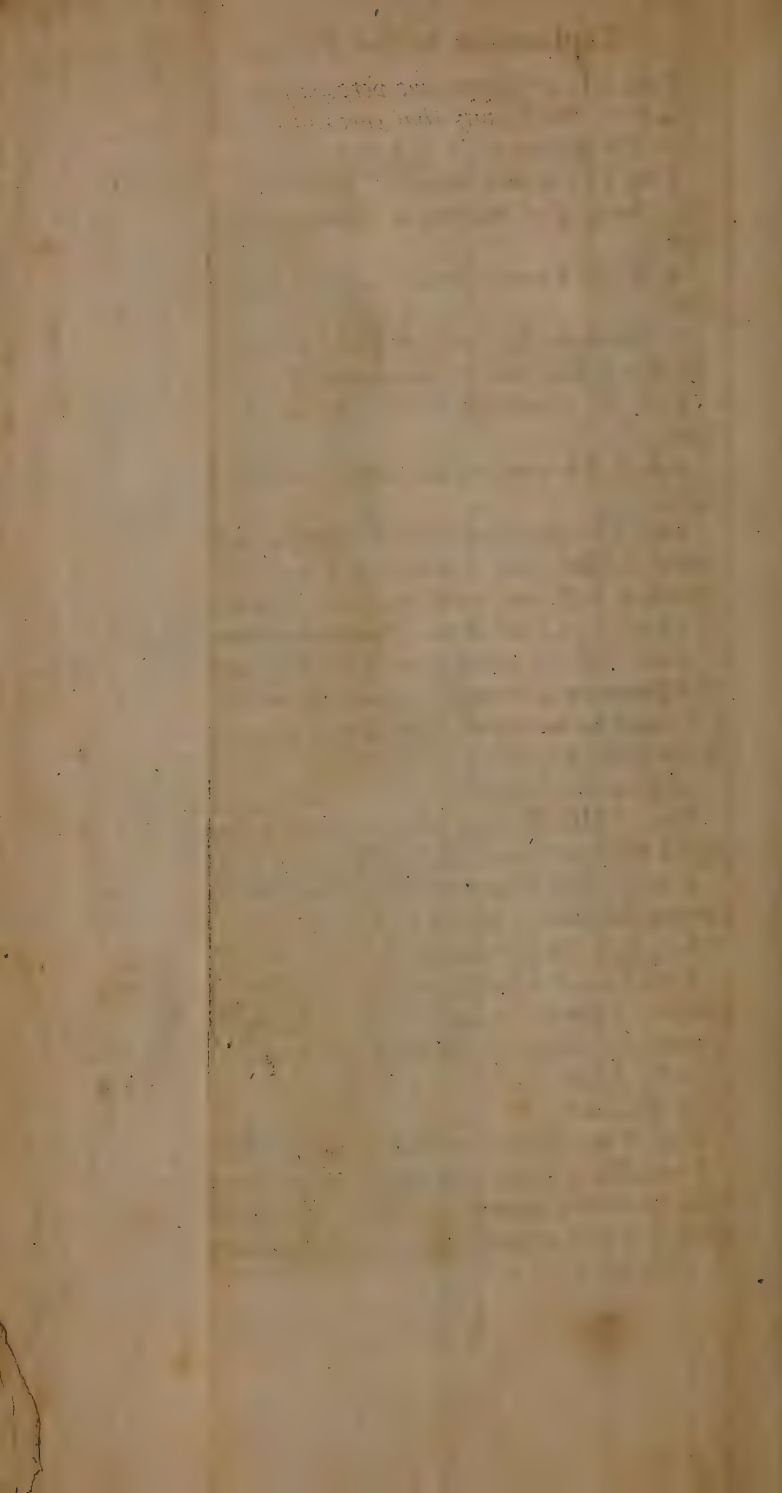


FIG. III. *A Coppel cut perpendicularly.*

a. b. c. *The Cavity that contains the Metal.*

d. *The Bottom of it (§ 176.)*

FIG. IV. *A Box made of Plate-brass, and open at Top; being $\frac{3}{4}$ of an Inch in Diameter, and three Inches high.*

a. b. *Its Cover, having at Top a fine close Hair-sieve.*

c. *Through the Pores of which the Ashes wherewith the Box is filled may be shaken out (§ 178.)*

FIG. V. *A wooden-Pestle like that FIG. I. to make Tests.*

a. b. c. *The convex Part which forms the Cavity of the Tests.*

FIG. VI. *An hollow wooden-Ring cut perpendicularly, which is filled with a Mass of Clay, and incompassed with a. a. b. b. an iron-Ring, lest it should break asunder (§ 187---191.) while the Matter is beaten into it.*

FIG. VII. *A scorificatory Test cut perpendicularly. The Diameter of it must be about two Inches. Its Bottom a. b. must be narrower, that it may sooner grow warm in the Fire (§ 186.)*

c. d. e. *Its Cavity.*

FIG. VIII. *A large ash-Vessel, or Coppel, incompassed with an iron-Ring h. i. k. l.*

a. b. c. *The Cavity of it, like a spherical Segment, surrounded with a Border d. e. f. g.*

h. i. k. l. *An iron-Ring, to retain the Ashes (§ 185.)*

FIG. IX. *A Shaver, curved according to the said spherical Segment, to cut the Ashes pressed close, in order to make the Cavity of the ash-Vessel (FIG. VIII.)*

a. *Its Edge.*

b. *Its Back.*

c. d. *Two Handles to hold it (§ 184. N^o 3.)*

FIG. X. *A Hand rowling about a smooth wooden-Ball, therewith to press close to the Cavity the dry bone-Ashes sprinkled upon it, that it may be made very smooth (§ 184. N^o 3. & 4.)*

FIG. XI. *A large ash-Vessel, framed in an earthen-Dish a. b. c. d.*

e. f. g. *Its Border (§ 184.)*

h. *Its spherical Cavity.*

FIG. XII. *A toothed, wooden-Pestle, to press close the Ashes put into the earthen Dish (§ 184. N^o 2.)*

FIG. XIII. *A small, semi-cylindrical Mould, to form the docimaistical Muffle.*

a. b. c. d. *Its convex Back.*

c. g. a. *Its hinder-Plane.*

b. d. e. f. *Its fore-Plane.*

h. *A Hole in the fore-Plane, wherein to fasten the Screw, p. with which the Mould may be pulled out, when the back and the hinder-Plane of it are covered with Clay closely applied to them (§ 199. N^o. 200.)*

FIG. XIV. *A concave Mould, which being applied to the foregoing (FIG. XIII.) the Muffles are made sooner, and more solid.*

l. *A semi-cylindrical Cavity, which is larger than the foregoing convex Mould (FIG. XIII.) to make the Thickness of the Muffle. The hollow Surface of it is done over with the clayey Matter.*

m. *The hinder-Board, where the Muffle must be close.*

r. *The fore-Board, which serves for pressing the Matter close.*

i. i. k. k. *Two Screws, the screw-holes of which are in the hinder-Board, to make the hinder and the fore-Board draw towards each other.*

o. n. *The upper-Board which makes the Bottom or Floor of the Muffle. It is furnished with another small transversal Board, q. that it may resist the Effort of the Screws g. g. (§ 200.)*

s. *The Nuts of the Screws g. g.*

P L A T E II.

FIG. I. *A docimaistical Muffle, with a fixt Bottom. It is seen on the fore-part, and side-ways (§ 194.)*

FIG. II. *A docimaistical Muffle set upon a moveable Bottom, and to be seen on the hinder-part, and laterally.*

FIG.

FIG. III. *A spheroidal Muffle, which is put upon the large Test surrounded with an iron-Ring (PLAT. I. FIG. VIII.) (§ 201.)*

FIG. IV. *A wooden-Mould, upon which the Mass of Clay designed to make the spheroidal Muffle (FIG. III.) is put (§ 201.)*

FIG. V. *A melting-Crucible with a broad fixt Foot. It serves chiefly to examine the Copper and Lead-ores (§ 202.)*

FIG. VI. *Another melting-Crucible triangular at Top, fit to pour out the melted Mass (§ 202.)*

FIG. VII. *A hollow wooden-Mould, cut perpendicularly, surrounded with an iron-Ring, divided into two Parts in the Middle, that it may be disjoined by taking off the iron-Ring. The small melting-Crucibles (FIG. V.) are made therein (§ 203.)*

FIG. VIII. *The Pestle belonging to the Mould (FIG. VII.) It serves to make the Cavity of the small melting Crucibles. FIG. V. (§ 203.)*

FIG. IX. *A hollow Mould, fit to make the triangular melting Crucibles FIG. VI. Cut likewise perpendicularly, and to be surrounded with an iron-Ring. There is a Pestle belonging to it, like that of FIG. VIII. The inferior Part of which, however, which forms the Cavity of the Crucible, must be of a triangular pyramidal Figure (§ 203.)*

FIG. X. *A. B. mark the Covers, to close the large and small melting Crucibles (§ 208.)*

FIG. XI. *A small separatory Cucurbite (§ 209.) with a Paper-Stopple.*

FIG. XII. *The Trevet whereon the small Cucurbite (FIG. XI.) rests (§ 210.)*

FIG. XIII. *The edulcoratory copper-Skellet, to wash the silver-Calx that has been precipitated out of Aqua Fortis by Copper (§ 211.)*

FIG. XIV. *A small golden-Dish to heat the Gold in red-hot, from which Silver has been eroded by Aqua Fortis (§ 212.)*

FIG. XV. *An iron-Trevet, whereon the small Dish (FIG. XIV.) is supported (§ 213.)*

FIG. XVI. *The wooden or earthen washing-Trough or Tray, to wash off the lighter and unprofitable Particles adhering to the Ores. It resembles a small Boat, is about one Foot long, and a few Inches broad and deep. The hinder and higher Part of it serves as a Handle to it (§ 214.)*

FIG. XVII. *The granulatory wooden Box (§ 215.)*

FIG. XVIII. *The granulatory cylindrical Machine, put upon a Vessel full of Water, so that its under-side may be immersed in the Water. The Metal to be granulated is poured upon it while it turns (§ 217.)*

FIG. XIX. *The melting Cone, which is of Copper or Iron (§ 220.)*

FIG. XX. *A Set of Moulds to make Ingots (§ 223.) of Metals.*

FIG. XXI. *A Mould with spherical Segments, for the metallick Regulus's which are to be put into the Coppel (§ 224.)*

P L A T E III.

FIG. I. *The Docimaetical or Essay-Furnace.*

a a. b b. c c. *The Body of the docimaetical Furnace (§ 232.)*

d. *Its Aperture at Top. (Ibid. N^o 1.)*

e. *The Door of the Ash-hole.*

k. k. *Sliders to shut the Door.*

f. *The upper-Door that is contiguous to the Muffle, which is seen within, in its proper Situation, together with two Coppels in it.*

l. l. *Sliders to shut the upper-Door.*

m. *An oblong Hole in one of the Sliders.*

n. *Another semi-circular Hole in the other Slider, through which one may look into the Muffle when the Door is shut.*

g. g. h. h. i. i. *Iron-Plates, rivetted to the Furnace, and making between them and the Sides of the Furnace, Grooves in which the Sliders of the Doors may move.*

o. o. *Two Holes, to which two others like them made in the hinder-part of the Furnace, do correspond, and through*

through which two small iron-Bars are introduced to sustain the Muffle.

p. A round Hole open in the upper-Part of the Furnace, that the Ashes and burning Coals may be stirred with a small iron-Rod introduced through it.

q. The Cover, which may be moved backward and foreward, between the iron-Plates c. c, rivetted to the Right and Left upper-Edge of the Furnace, and turned down.

r. A Segment of a Cylinder fastened at Top of the Cover q.

s. s. The Ears of the Cover, serving as a Funnel, or Flue, and upon which an iron-Pipe may be put.

t. The conick Tube to be put upon the Segment r. of the Cover, serving as a Funnel or Flue to excite the Fire.

FIG. II. A square Ledge divided into two Parts, and to be placed within, at Top of the upper-Border of the Door of the Ash-hole (FIG. I.) e. and upon which the Lute wherewith the Furnace is inwardly done over, and the prismatical iron-Bars which sustain the Grate, do rest.

FIG. III. Is the perpendicular Section of the Furnace (FIG. I.) passing through the Middle of the fore and hinder-Surface, that one may openly see the inward Disposition of the Furnace, as if one should look into it sideways.

FIG. IV. The Furnace cut perpendicularly, the Section passing through the Sides of it; to shew the inward Disposition, as if one should look into it backwards and forwards.

FIG. V. An elliptical wooden Mould, according to which the inward Cavity of the Furnace represented in the following FIG. must be formed.

a. The upper Part cut off, which forms (FIG. VII.) the inferior Extremity, must be cut off in the same Manner, to make the Body of the Furnace.

FIG. VI. The melting Furnace, made according to the Mould (FIG. V.)

d. An iron Ring, applied to the Border of the Furnace, to hold in the Lute wherewith the Inside of the

Furnace is done over. A like one is fastened at the lower Part of the Furnace.

e. e. Ears, to lift up and manage the Furnace.

c. c. Two Holes, facing which there are two other like ones behind, through which are passed the two small iron-Bars (FIG. XI.) wherewith the Grate (FIG. XII.) is supported.

FIG. VII. The Cover, to set upon the Furnace, when a strong Fire and Draft of Air is necessary. The Figure of it may be the Complement of the Part cut off of the Ellipsis (FIG. V.) a.

b. Is a Door hung on Hinges, through which the Fuel of the Fire is introduced into the Furnace.

c. c. The Ears of the Cover.

d. A Segment of a Cylinder, upon which an iron-Tube may be put in the Manner of a Funnel to increase the Fire; like that put upon the docimaistical Furnace FIG. I. t.

FIG. VIII. The Door of the Cover of FIG. VII. seen on the Inside, with a projecting iron Plate all round it, to fasten the Lute wherewith it is coated.

FIG. IX. The ash-Hole, or bottom-Part, on which the Furnace (FIG. VI.) is put.

c. An iron-Ring on which the Furnace is supported.

d. A Hole to introduce the Nofel of the Bellows.

b. A Door, to admit the Air, and take out the Ashes.

FIG. X. Another bottom-Part, coated within, and forming the Bed f. g. h. which receives the melted Metal.

c. A Hole to introduce the Poker.

d. A Hole for the Nofel of the Bellows.

e. A Hole from which the melted Matter may be let out of the Bed within, through a Channel that reaches from the Bottom of the said Bed g. down to the said Hole.

FIG. XI. Two small iron-Bars, which are introduced through the Holes o. o. of the docimaistical Furnace FIG. I. or through the Holes c. c. of the melting Furnace (FIG. VI.) in the former to support the docimaistical Muffle, and to support the Grate in the latter.

FIG. XII. The Grate for the melting Furnace.

FIG.

FIG. XIII. *The same bottom-Part of FIG. X. but so disposed, as that the melted Matter collected in the Bed of it, may be let out through the Hole e. FIG. X. and be received into a Bason i. placed on the Outside, surrounded with burning Coals.*

P L A T E IV.

FIG. I. *The Athanor (§ 242.)*

a. a. a. a. *The Tower of the Athanor, or chief Furnace, which receives the Fuel of the Fire: The pricked Lines indicate the Thickness of the Wall.*

b. b. b. b. *The inner Sides which form the Cavity, and are each ten Inches long.*

c. *The Door of the ash-Hole.*

e. *The upper-Door.*

d. *The Grate, which is placed even with the Bottom of the Door e.*

f. *The Cover wherewith the upper-Aperture of the Tower is shut.*

g. g. *A Flue, through which the Fire ascends from the Tower into the first Furnace.*

h. h. h. h. *A hollow Prisme, which forms the first secondary Furnace.*

i. i. *A semi-cylindrical Arch, wherewith the aforesaid Prisme is closed at Top.*

k. k. k. k. *An iron-Plate coated within, wherewith the fore-Part of the first secondary Furnace is shut.*

l. *A round Hole in the Plate k. k. k. k, through which the Neck of the Vessel 7. may be passed.*

m. *A Stopple, wherewith the Hole l. may be shut.*

n. n. *Iron-bars,*

o. o. o. o. *Iron-hooks fastened in the Wall, to receive the Iron-bars.*

6. *An iron-Door to shut the Flue g. g.*

p. p. p. p. *Iron-chains, with which the said Door may be lifted up.*

*. *. *Hooks on which the Door may be suspended with the Chains at any determined Height.*

q. q. q. q.

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q. q. q. q. *The Funnel of this Furnace.*

r. r. *An iron-Plate, wherewith the Funnel may be shut and opened.*

s. s. s. s. *A square Iron-Frame made of a double Plate, receiving the Plate r. r.*

t. t. *Another Flue, through which the Fire passes from the first secondary Furnace into the second.*

u. u. u. u. *Another secondary Furnace cylindrical.*

v. v. *Its upper circular Aperture, sloped at the fore-Part, to receive.*

w. w. *An iron-Pot which is to be hung in this second secondary Furnace.*

x. x. *An iron-Ring, by which the Pot w. w. rests upon the upper-Border of the Furnace.*

y. *A Segment cut out of the Pot, and corresponding with the foregoing v. v.*

z. *A Flue, which conveys the Fire from the second into the third Furnace.*

1. 1. 1. 1. *The Third secondary Furnace, like the second, and having also a Pot.*

2. 2. 2. 2. *The second Funnel.*

3. *A Plate, to shut open the Funnel.*

4. *An Aperture which leads from the third Furnace into the Funnel.*

5. 5. 5. *The third Funnel.*

7. *An earthen Retort, placed in the first secondary Furnace k. k. i. i. having its Neck through the Hole of the Door thereof.*

8. *A Recipient.*

9. *A glass-Retort, placed in the iron-Pot of the second secondary Furnace, which Pot is filled with Sand.*

10. *A Recipient.*

11. *A Cucurbite placed in the Pot of the third Furnace.*

12. *Stands, which support the Recipients, and which may be raised, or lowered with Screws.*

FIG. II. *A Pair of Tongs, to take the Tests and Coppels out of the Fire.*

a. *An iron-Rivett, wherewith the two Legs of the Tongs are joined.*

b. *The*

b. *The semi-lunar anterior Part of the Tongs, wherewith the Vessels are taken hold of.*

c. *The Ears wherewith the Tongs are laid hold of and managed.*

FIG. III. *A Pair of Pincers, to take up small Grains, and small Weights.*

FIG. IV. *A Pair of Tongs, to take Crucibles and other open Vessels of a middling Size, out of the Fire.*

FIG. V. *A Pair of Tongs, to embrace large Crucibles, and the largest Vessels charged with a great Quantity of Metal.*

a. *A single semi-Circle fastened at one of the Legs of the Tongs.*

b. *A double semi-Circle fastened at the other Leg, which intercepts the foregoing semi-Circle a, when you shut the Tongs.*

FIG. VI. *A small iron-Hook, to stir the Matter in the Tests put under the docimastical Muffle.*

FIG. VII. *A Rod of Iron, two Foot and an half long, and half an Inch thick, to stir the burning Coals and the Ashes upon the Convexity of the docimastical Muffle, put in the Furnace PLAT. III. FIG. I.*

FIG. VIII. *An iron-Hook, three Foot long, and from a quarter to half an Inch thick, to stir the Masses in the Crucibles put in the wind-Furnace.*

FIG. IX. *The Poker, wherewith the melted Metal or the Scorix in the large Test are stirred.*

FIG. X. *A Poker, to be introduced through the Door of the ash-Hole, to free the Grate of the Ashes or small Coals wherewith it is obstructed.*

FIG. XI. *A small iron-Ladle, with a long Handle, wherewith the Matter is put into the Vessels that are in the Fire.*

FIG. XII. *A wooden-Screen, with a Slit in it, a.*

FIG. XIII. *A cementatory or blow-Pipe.*

FIG. XIV. *A Smith's Forge not described indeed among the foregoing Furnaces, but easy to be known from this Figure, as much as is required in Practice.*

a. *A double Pair of Bellows.*

b. A

b. *A Hole made in the side Wall, through which the Nozel of the Bellows communicates with the Forge.*

c. *A small Pit, in which the Vessels or the larger Test may be put.*

FIG. XV. A. *a Furnace, for a large Test covered with a Muffle, the fore-Part of which is open, that the inward Disposition of it may be seen.*

a. *The Test.*

b. *The Muffle.*

c. c. *Two air-Holes, through which the Air may enter to excite the Fire.*

e. e. e. e. *Apertures which admits the Air.*

B. *A like Furnace, shut before.*

d. *A Door to which the Muffle is contiguous, that the Metal and Scoria's may be seen within, and stirred.*

P L A T. V.

FIG. I. *A Pair of double Bellows, with their Frame.*

a. a. a. a. *Iron-stays, fastened to the Uprights of the Frame of the Bellows, every one of which may receive the Trunions or Axles of the Bellows, that they may be raised or lowered at pleasure.*

b. b. *Iron-Keys, wherewith the Trunions are fastened, lest they should slip off when the Bellows are worked.*

c. c. *Two Uprights, which receive the Nozel of the Bellows.*

d. d. d. d. *Holes in the Uprights c. c.*

e. *An iron-Pin, which being passed through the Holes d. d. d. d. sustains the Nozel of the Bellows, that it may be raised or lowered.*

f. *A Weight, which distends the lower Part of the inferior Bellows.*

g. *A Weight, wherewith the upper Part of the Bellows are charged, that they may be pressed down by a determined Force.*

h. *The Handle, wherewith the Bellows are worked.*

i. .1

i. *A Chain, on which the Bellows are suspended, when at rest.*

FIG. II. *The docimaistical Balance.*

a. b. *The Beam.*

c. *The Tong.*

FIG. III. *The Fork.*

a a. *Two Holes, in which the Axis turns.*

d. d. *Two Holes, which retain the Clasp.*

c. *The Needle, which shews the Equilibrium.*

b. *An Aperture, that the Tongue (FIG. II. c.) may be seen in the Place where it corresponds to the Point of the Needle.*

FIG. IV. *The Clasp.*

FIG. V. A. A. *The Dishes, or Scales, which are suspended with Silk-strings, on the Extremities of the Beam (FIG. II.) a. b.*

B. B. *Two moveable Dishes, which, being loaded with the Weights and Things to be weighed, are put into the foregoing Dishes.*

FIG. VI. *The Support, on which the Balance is suspended.*

a. *The Pedestal.*

b. *The Pillar.*

c. *An Arm.*

d. *The first Pully.*

e. *The second Pully.*

f. *The third Pully.*

g. *Another Arm.*

h. *An oblong Hole.*

i. *A small Plate, to be introduced through the Hole h.*

k. *A Weight fastened on a Silk-string, where-with the Balance may be kept raised.*

FIG. VII. *A Case, in which the Balance is put up.*

a. a. a. *The Windows.*

b. *The Support (FIG. VI.) with the Balance.*

c. *The Silk-string conveyed through a small Hole made at bottom of the fore-Window, wherewith the Balance may be raised or lowered, when the Case is shut.*

e. e. Drawers, wherein the Weights, Scales, and other small Utenfils are put up.

FIG. VIII. It shews the Weights inclosed in a Box.

FIG. IX. The Proof-Needles, fastened together.

a. a. a. The Extremities of them which are rubbed against the Touch-stone.

FIG. X. The Touch-stone.

P L A T. VI.

FIG. I. The glass-Furnace to be seen on the fore-part.

A. The inferior Chamber, which is the ash-hole.

a. Its Door through which the Ashes are taken out, and the Wind is admitted either immediately or by Means of the Pipe b. which is conveyed thither from a Hole made in the Wall of the Laboratory.

c. The Place where the iron-Bars are put.

d. d. The Ledge upon which the Iron-bars rest, and whereon the Vessels are put.

B. The second Chamber, or fire-Place.

e. The great Door.

f. f. The smaller Doors.

C. The third Chamber.

g. A Hole, through which the Flame passes from the second into the third Chamber.

h. h. h. Doors.

i. i. The Hearth or Floor.

D. The fourth Chamber.

k. k. A quadrangular Hole for the Passage of the Fire.

l. The Door.

m. The Funnel.

n. n. n. n. &c. prickt Lines, shewing the Form of the inward Cavity of the Furnace.

o. o. o. o. o. o. Small Holes made through every Door.

FIG. II. The Furnace represented at the hinder-part.

FIG. III. The Picture of the Furnace cut perpendicularly in the Middle: Together with a Representation of

of the Vessels within. The Letters correspond with those of FIG. I.

FIG. IV. *A cylindrical Vessel shut close at Top.*

a. *A Hole through which the Matter may be put into it, and examined when therein.*

FIG. V. *A common triangular Crucible, adapted to the same Use as the foregoing FIG. IV.*



I N D E X.

A.

A Bathenen	Page 214	Alloy (mixt)	<i>ibid.</i>
Acids	29	Allum	172
— their dissolving		— Its Matrix's	<i>ibid.</i>
Virtue		— Generation	<i>ibid.</i>
— increased by Heat	30	— Preparation	413
Acid of Vitriol	<i>ibid.</i>	— Variety	<i>ibid.</i>
— Wine	<i>ibid.</i>	— (Plumose)	11
— (native Fossile)	<i>ibid.</i>	Aludels	189
— Allum	7	Amalgamation 21, 22, 180,	252
— Nitre	31	Amarill. See Smiris	
Its Production	31, 32	Amausa	447
— Nitre in the Cement	272	Amber	128
— Salt	38	Amianthus	11
It dissolves Silver the		Antimony	191
dry way	272	— (Crocus of)	358
Its Production	38	— (Eliquation of)	out
— Sulphur	7	of its Ore	356
— (vague Fossile)	<i>ibid.</i>	— (Liver of)	358
— (vegetable)	29	— (Ore of)	191
Æthiops Mineral	353	— (Regulus of)	5
Air too impetuous diminishes the		— It is volatile	24
Fire	298	— (Simple. Regulus of)	361
Alkali (fixt)	28	— By Metals	364
— Vitrifies Stones, and im-		— (Sulphur auratum of)	363
perfect Metals	28, 29	— (Fixt Sulphur of)	<i>ibid.</i>
— does not dissolve Gold		— It purifies Gold	277,
and Silver	<i>ibid.</i>		278
— rejects Mercury	29	— May be turned into	
— reduces Calxs of Metals		Glass	24
made with Acids	<i>ibid.</i>	— (Glass of)	359
— (native)	7	— Is very rapacious	24
— (volatile native)	<i>ibid.</i>	Its Rapaciousness in-	
Alloy	118	creases by a Phlogiston	<i>ibid.</i>
— (white)	<i>ibid.</i>	Anvil	99
		Apyri (Stones called)	10

Aqua

Aqua Fortis. See Acid of Nitre
 — Regis 38
 Arenarii (Stones called) 9
 Arsenick 6, 129
 — a semi-metal 5
 — lies hidden in several Minerals 131
 — fixes with Earths 22
 — penetrates Metals *ibid.*
 — & 23
 — is rapacious *ibid.*
 — (White Cryfalline) is fixt by Mercury 397
 — Fixt Alkali 400
 — Fixt alkaline Salt 401
 — Earths 392
 — Determines Earths to come to a Fusion *ibid.*
 — Does not take Flame with Nitre 294
 — Expels the Spirit of Nitre *ibid.*
 — (Pure) does not melt perfectly 396
 — (Yellow) *ibid.*
 — (Red) *ibid.*
 Art (docimaſtical) 1
 — Its Uſe in Metallurgy 198
 — Phyſick 199
 — Glaſs-making *ibid.*
 Aſbeſtus 11
 Asphaltum 128
 Atrament-ſtein. See Ink-ſtone

B.

Balance (docimaſtical) 100
 — Its Structure *ibid.*
 — Examination 103
 — Correction 104
 Berg blau 104
 Berg-grün *ibid.*
 Biſmuth 5, 25, 367
 — Ore 161
 — Is volatile in the Fire 368
 — (Sublimate of) reducible *ibid.*
 Bitumen 128

Bley-glantz 147
 — Klaar Spießiger *ibid.*
 Bley-fack 216
 — Schweiffig 149
 Blicken 213
 Blood-ſtone, or Blut-ſtein 137
 Bole 9
 Borax 40
 — Vitrifies Stones *ibid.*
 Box (granulating) 79
 Braſs 376
 Brine. See common Salt
 Brunſtein. See Manganefe

C.

Cadmia Fornacum 23, 26, 378
 Cœruleum Montanum 144
 Calaminaris (Lapis), or Calamine 140, 171, 376
 Calcination 190
 Calxs of Metals 26, 27, 443
 — (Refractory) *ibid.*
 Calx Caſſy 445
 Caratura. See Allay
 Cementation 270
 Cement-Kupfer 169
 — Waſſer *ibid.*
 — Pots 71
 Cements 46
 — (Gradatory) 274
 Ceruſſa Nigra 181
 Chalcitis 117
 Chalk 10
 — (Red). See red-Lead
 Chryſocolia. See Borax
 Cinnabar 159, 353
 — (Sublimation of) 354
 Clay 9
 Clœr 55
 Coals (Sea) 128
 Coating. See Lorication 74
 Cobalt 130, 162
 — (Flower of) 128
 Cone (melting) 71
 Contraſaits See Zink
 Coppelling 185
 Coppels 52
 — Are deſtroyed by Antimony 226
 H h Coppels

Coppels rendered black by the Scoria of Copper	227, 228, 300	Eliquation	192
Copper-Pyrites	145	— Of Silver out of Copper	328
— (Native)	143	per	328
— Ores	<i>ibid.</i> , and <i>fol.</i>	Elutriation	197
— (Precipitation of) out of its Ores	301, 303, 304	Encausta	446
Copper-Ore (the Roasting of)	<i>ibid.</i>	Errors to be avoided, proceeding from additional Ingredients	217
— The Washing of)	326	Examination of Ores, by Vitri-fications	424
— (Examination of)	327	— <i>&c.</i> is uncertain	425
by a moist Precipitation	311	— (Statical, and hydrostatical)	447
Copper (Regulus of Crude)	311		
— Lying hid in moist Menstrua is found out with Alkali	258		

— (Black)	307, 308, 316
— Is precipitated out of Iron by Sulphur	313
— Is purified by Scorification	208
— Freed from Iron by Lead	320, 321
— (melted) will not bear Cold nor Moisture	323
Coruscation. See Blicken	
Crucibles	66
Cucurbits (small separatory)	68

D.

Dish (The small golden)	69
Docimasia (Definition of)	1
— (Objects of)	<i>ibid.</i>
— (Use of)	13
— (End of)	<i>ibid.</i>
Durch-schweissen	343

E.

Earths	8
— (Sealed)	9
Edulcoration	195
Eisen-man, Eisen glimmer	139
— Grob-koernig, Grob-speissig	339
— Klaar-koernig, Klaar-speissig	346
— Schweissig	149
Electrum. See Amber	

Fahl-Ertz	145
— Kupfer Ertz	<i>ibid.</i>
Fallung	196
Figure (The) of Minerals is not constant	124
Fliegen-stein	394
Flint	9
Flowers	188
Flux	48
— (Reducing)	50
— (Black)	<i>ibid.</i>
— (White)	51
Fossils. See Minerals	
Fourthing. See Quartatio	
Furnace (docimastical)	75
— (Melting)	82
— (Description of the) of Glass-makers, for Experiments	427
Fusion	184

G.

Gahr-Kupfer	323
Galena	147
Garnate	151
Gist-Mehl	395
Glass	3, 185
— Gall	40
— Of Lead	18, 19
— Kopff. See Hæmatites	
Gold	2, 21
— (Native)	157, and <i>fol.</i>
Gold	

- Gold (Fulminating) 261
 ——— (Reduction of) 285
 Gold-folier 144
 ——— (Melting Precipitation of) 279
 ——— (The purifying of) with crude Antimony 275
 ——— Is not found in any proper Ore 158, and *fol.*
 ——— Resists Coppelling 259
 ——— Is separated from Silver by *Aqua Regis* 260
 Fortis 262
 Granulation of Lead 15
 ——— Tin 16
 Gravel 8, 9
 Gravity (specifick of Minerals) 124, 125
 Grit 8
 H.
 Hæmatites 137
 Hepar Sulphuris 315
 Hinterhalt 267
 I.
 Jeat 128
 Ink-stone 140
 Ingot an 72
 Iron 4
 ——— Ores 136
 ——— (Native) *ibid.*
 ——— Is attracted by the Load-stone 4, 337
 ——— Is not dissolved by Lead 224
 ——— When destroyed by Glass of Lead, is easily scorified *ibid.*
 ——— when mixt with Antimony, is not attracted by the Load-stone 337
 ——— when melted, loses its Malleability 340
 ——— Is freed from Sulphur, by absorbent terrestrial Bodies *ibid.*
 ——— Becomes malleable by Reduction, and by hammering 341
 ——— Turns to Steel, by a Cementation with inflammable fixt Bodies 344
 Melted with-Pitch-coal 347
 And by Fusion, and Hammering 348
 K.
 Kupfer-Grantz. 145
 ——— Glass-Ertz *ibid.*
 ——— Nickel. See Copper-Ores 131, 146
 ——— Leg 314
 ——— Stein 311
 ——— Waffer 169
 L.
 Lapis Lazuli 157
 Laboratory 123
 Lapis (Lebetum) 11
 Lead (Red) 11, 139
 Lead 2, 14, 15, 16
 ——— Calcines Tin 15
 ——— (Black) or Wad 181
 ——— (Native) 147
 ——— Ores *ibid.*
 ——— (Glass of) becomes very fusible and penetrating, by Arsenick 208
 ——— (Precipitation of) out of its Ores 292, 295, 297
 ——— Does not dissolve Iron 15
 ——— (Calxs of) ebulliate in the Reduction 291
 ——— (Reduction of) in an open Fire 296
 ——— (Separation of) from Copper, by Eliquation 298
 ——— (Pure) how known *ibid.*
 ——— Does not dissolve Copper, unless agitated by a strong Fire 300
 ——— Is soon scorified by Arsenick 222
 ——— To try, whether it contains any Copper 299
 Litharge 3, 15, 228
 ——— Turns Stones into Glass 17
 ——— Does not dissolve Metals unless they are destroyed *ibid.*
 Lorication, or Coating 74
 Luna Cornua 257
 ——— Is volatile 256

M.		(Matrixs of)	<i>ibid.</i>
Manganefe	138	Detonates with a Phlogiston	6
— (White)	419	Consumes imperfect Metals	42
Marble	10	— (Crystalization of)	416,
Marle	10, 11	— Becomes volatile in a great	417
Melenteria	171	Fire	247
Melting	184	— Becomes fixt, &c.	418
Menstrua	14	Detonates and becomes	
— (Moist)	<i>ibid.</i>	Alkali	<i>ibid.</i>
— (Dry)	<i>ibid.</i>	— Renders Gold and Silver	
Menstruum (Dry) of Metals	40, 41	malleable	248, 277
Mercury	4	O.	
— Is not a perfect Metal	<i>ibid.</i>	Offenbruch	26
— Is altogether volatile	<i>ibid.</i>	Oker of Iron	139
— (Native)	159	Okers (Copper)	144
— (Virgin)	<i>ibid.</i>	Ollaris (Lapis)	11
— (Ores)	<i>ibid.</i>	Ores	132
— Does not dissolve Iron,		— Crackle in the Fire	209,
nor Regulus of Antimony	22		221
— Amalgama	<i>ibid.</i>	— (Artificial)	133
— Is separated from amal-		— (Fusible)	<i>ibid.</i>
gamated Metals, by Filtration		— (Unfusible)	<i>ibid.</i>
and Distillation	254	— (Refractory)	<i>ibid.</i>
— &c. from Minerals	348	— (Differences of)	<i>ibid.</i>
— Is revived by Iron	354	— (Elutriable, or decantable)	135
Metal (Prince's)	25	— (Indecantable)	<i>ibid.</i>
Metals	2	Orpine, or Orpiment	129
Mica	11	P.	
Minerals	1, 2	Petroleum	128
— Are seldom pure	<i>ibid.</i>	Phlogiston enters into the Com-	
— (Classes of)	<i>ibid.</i>	position of Metals	26
— (Compound)	<i>ibid.</i> & 123	— Facilitates the melting	
— Not always known by		of Metals	27, 28
their Outside	13	Pix Judaica	128
— (Vitriolick)	140	Pompholyx	26, 375
— Proper	125	Pot (Melting)	66
— Improper	<i>ibid.</i>	Pots (Cement)	71
— Accidental	<i>ibid.</i>	Precipitating	192
Misy	171	Precipitation (Melting) or Preci-	
Molybdæna	181	pitation by Fusion	190, 191
Moulds (Set of)	72	— (Moist)	196
Muffle (Docimastical)	62	Processes. What they are	1
N.		— Their infinite Multi-	
Naphta	128	tude	<i>ibid.</i>
Nieder-Schlag	192	Pyrites (White)	129
Nihil Album	26	Pyrites	
— Gryseum	<i>ibid.</i> & 375		
Nitre	6, 177		
— (Generation of)	178		

Pyrites (Yellow) 127, 137
 — (Sulphureous) of Iron 171
 — Copper *ibid.*
 — Why refractory 221, 222

Q.

Quartatio 194
 Quartz 9

R.

Reduction 26, 186
 — Does not restore the
 Whole of the Metal *ibid.*
 — Is performed with a
 pure Phlogiston 27
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